

Supporting Information

Copper-Catalyzed Intermolecular Reductive Radical Difluoroalkylation-Thiolation of Aryl Alkenes

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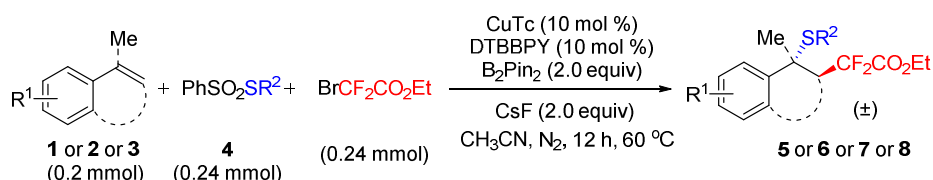
1) General Information

NMR spectra were recorded on Bruker Avance III 500 MHz spectrometer (500 MHz for ^1H ; 471 MHz for ^{19}F ; 126 MHz for ^{13}C). The chemical shifts (δ) are given in parts per million relative to CDCl_3 (7.26 ppm for ^1H) and CDCl_3 (77.05 ppm for ^{13}C). The following abbreviations are used to illuminate the diversities: δ , chemical shift; J, coupling constant; s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet. High resolution mass spectra were recorded using a Waters Micromass GCT Premier. For chromatography, 200-300 mesh silica gel (Qingdao, China) was employed.

Unless otherwise noted, materials obtained from commercial suppliers were used without further purification. All solvents were purified according to standard procedures. Benzenesulfonothioates were readily prepared according to the related literatures.¹

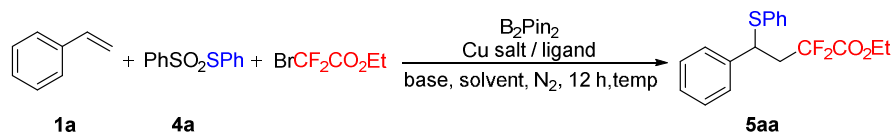
2) General Procedure for Cu-Catalyzed Reductive

Thiodifluoroalkylation of Aryl Olefins



To a flame dried Schlenk tube equipped with a stirring bar were added benzenesulfonothioates **4** (0.24 mmol), B_2pin_2 (2.0 equiv), CsF (2.0 equiv), CuTc (10 mol %) and DTBBPY (10 mol %), then dry CH_3CN (2 mL), aryl olefins **1** or **2** or **3** (0.2 mmol) and $\text{BrCF}_2\text{CO}_2\text{Et}$ (0.24 mmol) were added sequentially under N_2 . The reaction mixture was stirred at 60 °C for 12 h. After that, the reaction mixture was concentrated *in vacuo* and the desired product was obtained by flash column chromatography on silica gel.

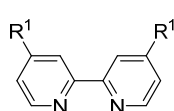
3) Optimization Reaction Conditions ^a



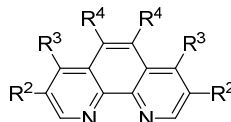
entry	Cu salt (w mol %)	ligand (x mol %)	B_2pin_2 (y equiv)	base (z equiv)	solvent (2 ml)	temp.	yield $^{\circ}$ (%)
1	$\text{Cu}(\text{OAc})_2 \cdot \text{H}_2\text{O}$ (10)	L1 (10)	1.2	K_2CO_3 (1.2)	CH_3CN	rt	28
2	$\text{Cu}(\text{OAc})_2 \cdot \text{H}_2\text{O}$ (10)	L1 (10)	1.2	KOtBu (1.2)	CH_3CN	rt	33
3	$\text{Cu}(\text{OAc})_2 \cdot \text{H}_2\text{O}$ (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	49
4	$\text{Cu}(\text{OAc})_2 \cdot \text{H}_2\text{O}$ (10)	L1 (10)	1.2	K_3PO_4 (1.2)	CH_3CN	rt	37
5	CuCl (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	52
6	CuBr (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	49
7	CuI (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	49
8	CuCl_2 (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	51
9	CuTc (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	55
10	Cu_2O (5)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	54
11	$\text{Cu}(\text{OTf})_2$ (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	43
12	$\text{CuF} \cdot n\text{H}_2\text{O}$ (10)	L1 (10)	1.2	CsF (1.2)	CH_3CN	rt	51

13	CuTc (10)	L2 (10)	1.2	CsF (1.2)	CH ₃ CN	rt	N.D.
14	CuTc (10)	L3 (10)	1.2	CsF (1.2)	CH ₃ CN	rt	51
15	CuTc (10)	L4 (10)	1.2	CsF (1.2)	CH ₃ CN	rt	43
16	CuTc (10)	L5 (10)	1.2	CsF (1.2)	CH ₃ CN	rt	trace
17	CuTc (10)	L6 (10)	1.2	CsF (1.2)	CH ₃ CN	rt	44
18	CuTc (10)	L7 (10)	1.2	CsF (1.2)	CH ₃ CN	rt	52
19	CuTc (10)	L8 (10)	1.2	CsF (1.2)	CH ₃ CN	rt	29
20	CuTc (10)	Xantphos (10)	1.2	CsF (1.2)	CH ₃ CN	rt	N.D.
21	CuTc (10)	L1 (10)	1.2	CsF (1.2)	Toluene	rt	N.D.
22	CuTc (10)	L1 (10)	1.2	CsF (1.2)	THF	rt	N.D.
23	CuTc (10)	L1 (10)	1.2	CsF (1.2)	DMF	rt	N.D.
24	CuTc (10)	L1 (10)	1.2	CsF (1.2)	1,4-dioxane	rt	N.D.
25 ^b	CuTc (10)	L1 (10)	0	CsF (1.2)	CH ₃ CN	rt	N.D.
26	CuTc (10)	L1 (10)	0	CsF (1.2)	CH ₃ CN	rt	N.D.
27	CuTc (10)	L1 (10)	0.3	CsF (1.2)	CH ₃ CN	rt	25
28	CuTc (10)	L1 (10)	0.6	CsF (1.2)	CH ₃ CN	rt	44
29	CuTc (10)	L1 (10)	2.0	CsF (2.0)	CH ₃ CN	60	79 (73 ^d)

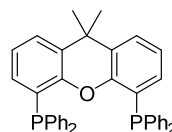
^a **1a** (0.2 mmol), **4a** (0.24 mmol), BrCF₂CO₂Et (0.24 mmol), Cu salt (w mol %), ligand (x mol %), B₂Pin₂ (y equiv), CsF (z equiv), CH₃CN (2 mL), N₂, 12 h, temp;^b Zn power (1.2 equiv) were used instead of B₂pin₂; ^c GC yield; ^d isolated yield.



L1: R¹ = ^tBu
L2: R¹ = H
L3: R¹ = Me
L4: R¹ = OMe

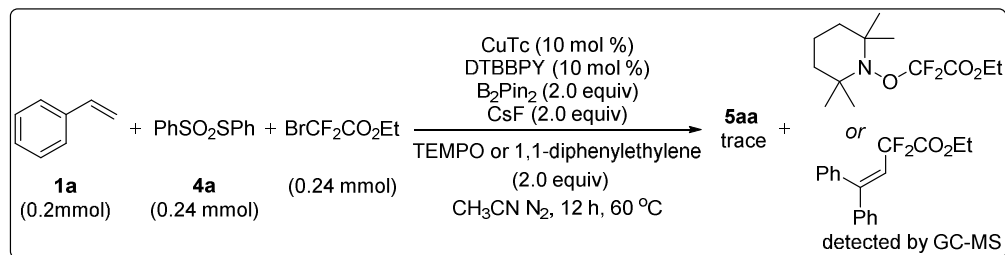


L5: R² = H, R³ = H, R⁴ = H
L6: R² = H, R³ = Me, R⁴ = H
L7: R² = Me, R³ = Me, R⁴ = H
L8: R² = H, R³ = Ph, R⁴ = H



Xantphos

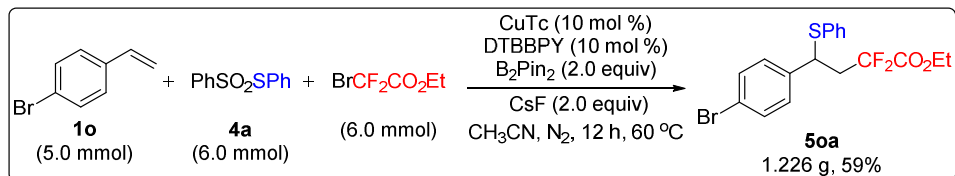
4) Experimental Probes on Reaction Mechanism



To a flame dried Schlenk tube equipped with a stirring bar were added PhSO₂SPh **4a** (0.24 mmol), B₂pin₂ (2.0 equiv), CsF (2.0 equiv), TEMPO or 1,1-diphenylethylene (2.0 equiv), CuTc (10 mol %) and DTBBPY (10 mol %), then dry CH₃CN (2 mL), styrene **1a** (0.2 mmol) and BrCF₂CO₂Et (0.24 mmol) were added sequentially under N₂. The reaction mixture was stirred at 60 °C for 12 h. After that, the mixture was diluted with ethyl acetate. The amount of **5aa** was detected by TLC and GC-MS.

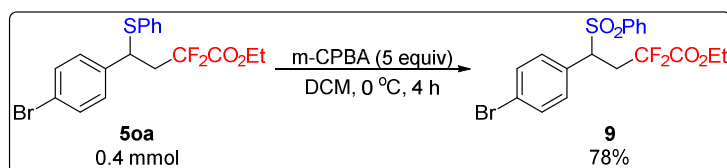
5) Synthetic Applications

Procedure for Scaled up Reaction



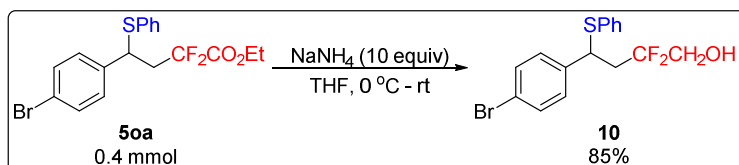
To a flame dried Schlenk tube equipped with a stirring bar were added PhSO₂SPh **4a** (6 mmol), B₂pin₂ (2.0 equiv), CsF (2.0 equiv), CuTc (10 mol %) and DTBBPY (10 mol %), then dry CH₃CN (50 mL), aryl olefin **1o** (5 mmol) and BrCF₂CO₂Et (6 mmol) were added sequentially under N₂. The reaction mixture was stirred at 60 °C for 12 h. After that, the reaction mixture was concentrated *in vacuo* and the desired product was obtained by flash column chromatography on silica gel.

Procedure for Oxidizing **5oa** into Its Sulphone Derivative **9**



To a solution of **5oa** (0.4 mmol) in dry CH₂Cl₂ (6 mL) was added m-CPBA (5 equiv) gradually at 0 °C, the solution was stirred at this temperature for 4 h. After that, the mixture was diluted with sat. NaHCO₃ (5 mL) and extracted with DCM (3 × 5 mL). The organic layers were combined and concentrated under vacuo. The residue was purified by flash column chromatography on silica gel using petroleum ether and ethyl acetate (10:1) as eluent to afford **9** as white solid.

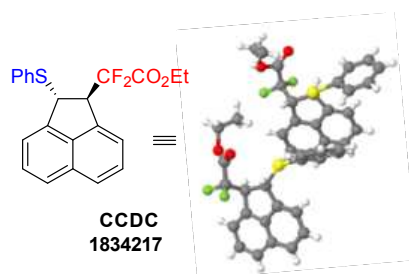
Procedure for Reducing **5oa** into Its Alcohol Derivative **10**



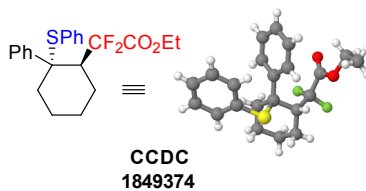
To a solution of **5oa** (0.4 mmol) in dry THF (6 mL) was added NaBH₄ (10 equiv) gradually at 0 °C. Then the mixture was stirred under room temperature. After **5oa** was consumed completely (detected by TLC), the crude production was diluted with saturated NaCl solution and then extracted with DCM (3 times). The organic layers were combined and concentrated under vacuo. The residue was purified by flash column chromatography on silica gel using petroleum ether and ethyl acetate (20:1) as eluent to afford **10** as colorless oil.

6) Crystal data of **7fa** and **7ga**

Crystallographic data for compound **7fa** (CCDC-1834217) and **7ga** (CCDC-1849374) have been deposited with the Cambridge Crystallographic Data Centre. Copies of the datum can be obtained, free of charge, on application to CCDC (Email: deposit@ccdc.cam.ac.uk).

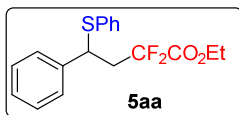


Bond precision:	C-C = 0.0087 Å	Wavelength=0.71073
Cell:	a=19.1333(10) alpha=90	b=10.4014(6) beta=90
Temperature:	296 K	c=18.5449(11) gamma=90
	Calculated	Reported
Volume	3690.7(4)	3690.7(4)
Space group	P n a 21	P n a 21
Hall group	P 2c -2n	P 2c -2n
Moiety formula	C22 H18 F2 O2 S	C22 H18 F2 O2 S
Sum formula	C22 H18 F2 O2 S	C22 H18 F2 O2 S
Mr	384.42	384.45
Dx, g cm ⁻³	1.384	1.384
Z	8	8
Mu (mm ⁻¹)	0.209	0.209
F000	1600.0	1601.9
F000'	1601.85	
h, k, lmax	22, 12, 22	22, 12, 22
Nref	6497[3359]	6220
Tmin, Tmax		0.489, 1.000
Tmin'		
Correction method= # Reported T Limits: Tmin=0.489 Tmax=1.000		
AbsCorr = MULTI-SCAN		
Data completeness= 1.85/0.96	Theta(max)= 25.000	
R(reflections)= 0.0502(3901)	wR2(reflections)= 0.1617(6220)	
S = 0.862	Npar= 488	

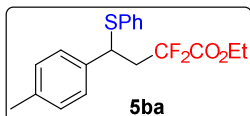


Bond precision:	C-C = 0.0050 Å	Wavelength=0.71073	
Cell:	a=8.8546(14)	b=18.774(2)	c=24.292(3)
	alpha=90	beta=90	gamma=90
Temperature:	298 K		
	Calculated	Reported	
Volume	4038.2(9)	4038.2(10)	
Space group	P b c a	P b c a	
Hall group	-P 2ac 2ab	-P 2ac 2ab	
Moiety formula	C22 H24 F2 O2 S	C22 H24 F2 O2 S	
Sum formula	C22 H24 F2 O2 S	C22 H24 F2 O2 S	
Mr	390.47	390.50	
Dx,g cm-3	1.285	1.285	
Z	8	8	
Mu (mm-1)	0.192	0.192	
F000	1648.0	1649.9	
F000'	1649.85		
h,k,lmax	10,22,28	10,22,28	
Nref	3553	3538	
Tmin,Tmax		0.008,1.000	
Tmin'			
Correction method= # Reported T Limits: Tmin=0.008 Tmax=1.000			
AbsCorr = MULTI-SCAN			
Data completeness= 0.996		Theta(max)= 25.000	
R(reflections)= 0.0644(2435)		wR2(reflections)= 0.1960(3538)	
S = 1.195		Npar= 245	

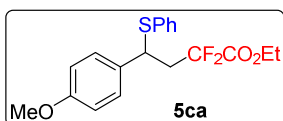
7) Characterization Data of Products



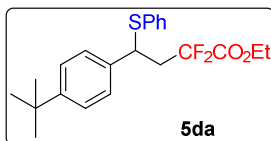
ethyl 2,2-difluoro-4-phenyl-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (49 mg, 73%), m.p. = 45.4-48.1 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.40-7.13 (m, 10H), 4.37 (dd, *J* = 9.2, 5.1 Hz, 1H), 4.11-3.79 (m, 2H), 3.03-2.56 (m, 2H), 1.20 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.49 (t, *J* = 32.4 Hz), 139.63, 133.44, 133.15, 128.99, 128.44, 128.00, 127.96, 127.82, 114.80 (t, *J* = 251.6 Hz), 62.88, 46.89 (t, *J* = 4.9 Hz), 40.57 (t, *J* = 23.8 Hz), 13.71; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.31 (d, *J* = 261.8 Hz, 1F), -105.05 (d, *J* = 261.8 Hz, 1F); HRMS (ESI) calcd for C₁₈H₁₈F₂O₂SNa⁺ [M+Na]⁺ 359.0888; found: 359.0890.



ethyl 2,2-difluoro-4-(phenylthio)-4-(p-tolyl)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (50 mg, 71%), m.p. = 53.8-55.1 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.34-7.28 (m, 2H), 7.28-7.20 (m, 3H), 7.09 (dt, *J* = 26.1, 13.0 Hz, 4H), 4.36 (dd, *J* = 9.3, 5.0 Hz, 1H), 4.07-3.82 (m, 2H), 2.95-2.60 (m, 2H), 2.31 (s, 3H), 1.20 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.53 (t, *J* = 32.4 Hz), 137.55, 136.51, 133.74, 132.90, 129.12, 128.98, 127.86, 127.81, 114.84 (t, *J* = 251.5 Hz), 62.85, 47.88-43.22 (m), 40.66 (t, *J* = 23.6 Hz), 21.12, 13.69; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.35 (d, *J* = 261.7 Hz, 1F), -105.05 (d, *J* = 261.7 Hz, 1F); HRMS (ESI) calcd for C₁₉H₂₀F₂O₂SNa⁺ [M+Na]⁺ 373.1044; found: 373.1041.

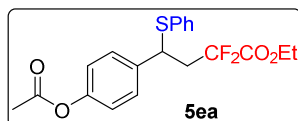


ethyl 2,2-difluoro-4-(4-methoxyphenyl)-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 50:1. White solid (46 mg, 62%), m.p. = 73.3-75.4 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.32-7.27 (m, 2H), 7.27-7.23 (m, 3H), 7.17-7.12 (m, 2H), 6.82-6.77 (m, 2H), 4.35 (dd, *J* = 9.5, 4.9 Hz, 1H), 3.97 (qq, *J* = 10.9, 7.2 Hz, 2H), 3.77 (s, 3H), 2.92-2.59 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.51 (t, *J* = 32.4 Hz), 159.10, 133.66, 133.03, 131.45, 129.10, 128.98, 127.89, 114.83 (t, *J* = 251.9 Hz), 113.77, 62.87, 55.27, 47.84-43.20 (m), 40.70 (t, *J* = 23.6 Hz), 13.71; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.18 (d, *J* = 261.6 Hz, 1F), -105.27 (d, *J* = 261.7 Hz, 1F); HRMS (ESI) calcd for C₁₉H₂₀F₂O₃SNa⁺ [M+Na]⁺ 389.0993; found: 389.0998.

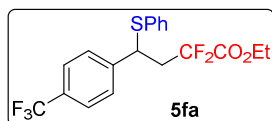


ethyl 4-(4-(tert-butyl)phenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column

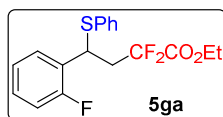
chromatography: petroleum ether: ethyl acetate = 100:1. White solid (51 mg, 65%), m.p. = 35.1-37.4 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.37-7.26 (m, 7H), 7.22-7.17 (m, 2H), 4.39 (dd, J = 9.6, 4.7 Hz, 1H), 3.98-3.78 (m, 2H), 2.99-2.64 (m, 2H), 1.31 (s, 9H), 1.18 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.49 (t, J = 32.3 Hz), 150.82, 136.18, 133.83, 132.84, 128.98, 127.83, 127.64, 125.36, 114.80 (t, J = 251.9 Hz), 62.76, 49.48-44.34 (m), 40.66 (t, J = 23.7 Hz), 34.54, 31.28, 13.68; ^{19}F NMR (471 MHz, CDCl_3) δ -101.59 (d, J = 261.3 Hz, 1F), -105.74 (d, J = 261.3 Hz, 1F); HRMS (ESI) calcd for $\text{C}_{22}\text{H}_{26}\text{F}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 415.1514; found: 415.1514.



ethyl 4-(4-acetoxyphenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 50:1. White solid (46 mg, 58%), m.p. = 70.0-72.2 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.33-7.26 (m, 5H), 7.25-7.21 (m, 2H), 7.03-6.98 (m, 2H), 4.39 (dd, J = 9.1, 5.2 Hz, 1H), 4.10-3.90 (m, 2H), 2.95-2.65 (m, 2H), 2.30 (s, 3H), 1.23 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 169.19, 163.44 (t, J = 32.3 Hz), 150.12, 137.14, 133.33, 133.13, 129.04, 128.98, 128.16, 121.55, 114.70 (t, J = 252.0 Hz), 63.06, 48.19-43.73 (m), 40.62 (t, J = 23.9 Hz), 21.12, 13.74; ^{19}F NMR (471 MHz, CDCl_3) δ -102.12 (d, J = 261.9 Hz, 1F), -105.27 (d, J = 262.0 Hz, 1F); HRMS (ESI) calcd for $\text{C}_{20}\text{H}_{20}\text{F}_2\text{O}_4\text{SNa}^+ [\text{M}+\text{Na}]^+$ 417.0943; found: 417.0945.

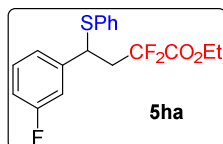


ethyl 2,2-difluoro-4-(phenylthio)-4-(4-(trifluoromethyl)phenyl)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (40 mg, 50%), m.p. = 88.5-90.5 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.54 (d, J = 8.2 Hz, 2H), 7.34 (d, J = 8.1 Hz, 2H), 7.32-7.25 (m, 5H), 4.42 (dd, J = 15.5, 8.1 Hz, 1H), 4.13-3.95 (m, 2H), 2.94-2.68 (m, 2H), 1.25 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.41 (t, J = 32.2 Hz), 144.13, 133.54, 132.58, 129.89 (q, J = 32.5 Hz), 129.13, 128.47, 128.28, 125.38 (q, J = 3.7 Hz), 123.94 (t, J = 272.2 Hz), 114.61 (t, J = 252.1 Hz), 63.06, 46.66 (t, J = 4.5 Hz), 40.27 (t, J = 23.8 Hz), 13.71; ^{19}F NMR (471 MHz, CDCl_3) δ -62.63 (s, 3F), -103.15 (d, J = 262.8 Hz, 1F), -104.31 (d, J = 262.8 Hz, 1F); HRMS (ESI) calcd for $\text{C}_{19}\text{H}_{17}\text{F}_5\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 427.0762; found: 427.0762.

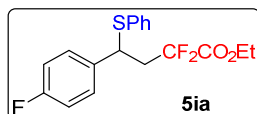


ethyl 2,2-difluoro-4-(2-fluorophenyl)-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (45 mg, 64%). ^1H NMR (500 MHz, CDCl_3) δ 7.37-7.31 (m, 2H), 7.30-7.26 (m, 3H), 7.23 (dt, J = 7.4, 4.6 Hz, 2H), 7.11-7.05 (m, 1H), 7.01 (ddd, J = 8.9, 6.9, 1.4 Hz, 1H), 4.73 (dd, J = 9.2, 5.3 Hz, 1H), 4.15-3.95 (m, 2H), 3.02-2.67 (m, 2H), 1.27 (t, J = 6.2 Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.49 (t, J = 32.4 Hz), 160.21 (d, J = 248.1 Hz), 133.33, 133.07, 129.33 (d, J = 8.5 Hz), 129.13 (d, J = 3.5 Hz), 129.01, 128.20, 127.05 (d, J = 13.1 Hz), 124.09 (d, J = 3.6 Hz), 115.61 (d, J = 22.2 Hz), 114.71 (t,

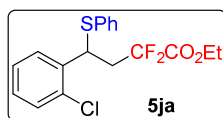
$J = 252.0$ Hz), 62.99, 39.94 (t, $J = 5.6$ Hz), 39.64 (t, $J = 23.1$ Hz), 13.73; ^{19}F NMR (471 MHz, CDCl_3) δ -103.66 (d, $J = 262.4$ Hz, 1F), -104.55 (d, $J = 262.4$ Hz, 1F), -116.89 (s, 1F); HRMS (ESI) calcd for $\text{C}_{18}\text{H}_{17}\text{F}_3\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 377.0794; found: 377.0796.



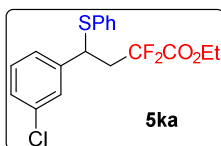
ethyl 2,2-difluoro-4-(3-fluorophenyl)-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (54 mg, 77%). ^1H NMR (500 MHz, CDCl_3) δ 7.30-7.23 (m, 5H), 7.22-7.18 (m, 1H), 7.00-6.88 (m, 3H), 4.35 (dd, $J = 8.6$, 5.7 Hz, 1H), 4.19-3.95 (m, 2H), 2.92-2.56 (m, 2H), 1.24 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.16 (t, $J = 28.0$ Hz), 162.66 (d, $J = 246.4$ Hz), 142.50 (d, $J = 7.0$ Hz), 133.39, 132.88, 129.91 (d, $J = 8.3$ Hz), 129.06, 128.29, 123.68 (d, $J = 2.7$ Hz), 114.84 (d, $J = 9.1$ Hz), 114.67 (d, $J = 7.9$ Hz), 114.64 (t, $J = 252.0$ Hz), 63.00, 46.59 (t, $J = 4.4$ Hz), 40.44 (t, $J = 23.8$ Hz), 13.73; ^{19}F NMR (471 MHz, CDCl_3) δ -103.00 (d, $J = 262.7$ Hz, 1F), -104.53 (d, $J = 262.7$ Hz, 1F), -112.73 (d, $J = 2.2$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{18}\text{H}_{17}\text{F}_3\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 377.0794; found: 377.0798.



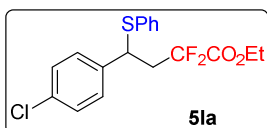
ethyl 2,2-difluoro-4-(4-fluorophenyl)-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (49 mg, 69%), m.p. = 55.1-56.8 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.30-7.22 (m, 5H), 7.21-7.15 (m, 2H), 6.98-6.91 (m, 2H), 4.36 (dd, $J = 8.9$, 5.5 Hz, 1H), 4.12-3.91 (m, 2H), 2.91-2.64 (m, 2H), 1.23 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.45 (t, $J = 32.3$ Hz), 162.11 (d, $J = 246.8$ Hz), 135.57 (d, $J = 3.2$ Hz), 133.37, 133.06, 129.58 (d, $J = 8.2$ Hz), 129.04, 128.20, 115.30 (d, $J = 21.6$ Hz), 114.72 (t, $J = 252.0$ Hz), 62.96, 46.25 (t, $J = 4.7$ Hz), 40.59 (t, $J = 23.7$ Hz), 13.74; ^{19}F NMR (471 MHz, CDCl_3) δ -102.71 (d, $J = 262.3$ Hz, 1F), -104.77 (d, $J = 262.2$ Hz, 1F), -114.13 (s, 1F); HRMS (ESI) calcd for $\text{C}_{18}\text{H}_{17}\text{F}_3\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 377.0794; found: 377.0796.



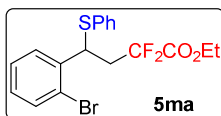
ethyl 4-(2-chlorophenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (49 mg, 66%). ^1H NMR (500 MHz, CDCl_3) δ 7.33 (ddd, $J = 9.1$, 5.0, 3.0 Hz, 4H), 7.29-7.25 (m, 3H), 7.22 (td, $J = 7.5$, 1.3 Hz, 1H), 7.17 (td, $J = 7.6$, 1.7 Hz, 1H), 5.03 (dd, $J = 24.6$, 18.4 Hz, 1H), 4.17-3.97 (m, 2H), 2.99-2.60 (m, 2H), 1.25 (t, $J = 7.1$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.53 (t, $J = 32.3$ Hz), 137.23, 133.63, 133.33, 132.92, 129.72, 129.02, 128.92, 128.79, 128.21, 126.95, 114.67 (t, $J = 252.2$ Hz), 63.02, 42.65 (t, $J = 4.7$ Hz), 39.92 (t, $J = 23.7$ Hz), 13.75; ^{19}F NMR (471 MHz, CDCl_3) δ -103.61 (s, 2F); HRMS (ESI) calcd for $\text{C}_{18}\text{H}_{17}\text{ClF}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 393.0498; found: 393.0499.



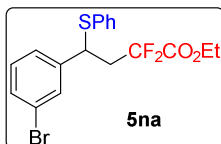
ethyl 4-(3-chlorophenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: petroleum ether: ethyl acetate = 100:1. Colorless oil (47 mg, 64%). ^1H NMR (500 MHz, CDCl_3) δ 7.31-7.24 (m, 5H), 7.23-7.15 (m, 3H), 7.10-7.04 (m, 1H), 4.37-4.27 (m, 1H), 4.12-3.98 (m, 2H), 2.88-2.65 (m, 2H), 1.25 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.40 (t, $J = 32.3$ Hz), 141.94, 134.24, 133.47, 132.78, 129.69, 129.09, 128.37, 127.96, 127.94, 126.22, 114.63 (t, $J = 252.0$ Hz), 63.06, 46.56 (t, $J = 5.0$ Hz), 40.36 (t, $J = 23.8$ Hz), 13.74; ^{19}F NMR (471 MHz, CDCl_3) δ -102.77 (d, $J = 262.6$ Hz, 1F), -104.63 (d, $J = 262.7$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{18}\text{H}_{17}\text{ClF}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 393.0498; found: 393.0497.



ethyl 4-(4-chlorophenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: petroleum ether: ethyl acetate = 100:1. White solid (51 mg, 69%), m.p. = 69.5-71.0 $^\circ\text{C}$. ^1H NMR (500 MHz, CDCl_3) δ 7.30-7.21 (m, 7H), 7.17-7.12 (m, 2H), 4.34 (dd, $J = 8.4, 5.9$ Hz, 1H), 4.13-3.93 (m, 2H), 2.85-2.65 (m, 2H), 1.23 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.45 (t, $J = 32.4$ Hz), 138.44, 133.48, 133.40, 132.90, 129.26, 129.08, 128.57, 128.28, 114.68 (t, $J = 251.9$ Hz), 63.03, 46.37 (t, $J = 4.7$ Hz), 40.43 (t, $J = 23.7$ Hz), 13.74; ^{19}F NMR (471 MHz, CDCl_3) δ -102.90 (d, $J = 262.4$ Hz, 1F), -104.54 (d, $J = 262.5$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{18}\text{H}_{17}\text{ClF}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 393.0498; found: 393.0500.

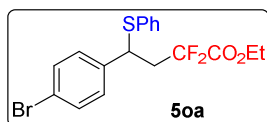


ethyl 4-(2-bromophenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (53 mg, 64%). ^1H NMR (500 MHz, CDCl_3) δ 7.55-7.49 (m, 1H), 7.38-7.31 (m, 3H), 7.29-7.23 (m, 4H), 7.12-7.06 (m, 1H), 5.00 (m, 1H), 4.21-3.96 (m, 2H), 2.96-2.64 (m, 2H), 1.25 (t, $J = 7.2$ Hz, 4H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.54 (t, $J = 32.1$ Hz), 138.78, 133.40, 133.05, 132.82, 129.07, 129.02, 128.23, 127.60, 124.39, 114.64 (t, $J = 252.4$ Hz), 99.99, 63.03, 46.72-43.67 (m), 40.00 (t, $J = 24.0$ Hz), 13.77; ^{19}F NMR (471 MHz, CDCl_3) δ -103.44 (s, 2F); HRMS (ESI) calcd for $\text{C}_{18}\text{H}_{17}\text{BrF}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 436.9993; found: 436.9993.

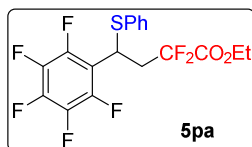


ethyl 4-(3-bromophenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (54 mg, 65%). ^1H NMR (500 MHz, CDCl_3) δ 7.38-7.33 (m, 2H), 7.30-7.24 (m, 5H), 7.15-7.09 (m, 2H), 4.30 (dd, $J = 8.7, 5.6$ Hz, 1H), 4.15-3.96 (m, 2H), 2.89-2.63 (m, 2H), 1.25 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz,

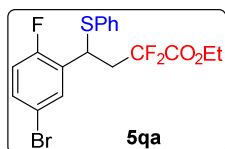
CDCl₃) δ 163.40 (t, J = 32.3 Hz), 142.18, 133.51, 132.74, 130.86, 129.97, 129.10, 128.39, 126.68, 122.38, 114.62 (t, J = 251.9 Hz), 63.08, 46.52 (t, J = 4.7 Hz), 40.35 (t, J = 23.8 Hz), 13.77; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.74 (d, J = 262.7 Hz, 1F), -104.05 – -105.25 (m, 1F); HRMS (ESI) calcd for C₁₈H₁₇BrF₂O₂SNa⁺ [M+Na]⁺ 436.9993; found: 436.9990.



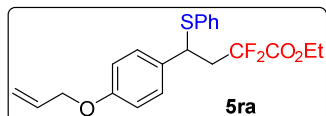
ethyl 4-(4-bromophenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (49 mg, 59%), m.p. = 74.5-76.9 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.41-7.36 (m, 2H), 7.30-7.22 (m, 4H), 7.11-7.06 (m, 2H), 4.32 (dd, J = 8.4, 6.0 Hz, 1H), 4.12-3.94 (m, 2H), 2.84-2.62 (m, 2H), 1.23 (t, J = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.45 (t, J = 32.2 Hz), 138.98, 133.39, 132.87, 131.53, 129.59, 129.09, 128.30, 121.60, 114.67 (t, J = 251.9 Hz), 63.04, 46.44 (t, J = 4.6 Hz), 40.38 (t, J = 23.7 Hz), 13.75; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.91 (d, J = 262.4 Hz, 1F), -104.52 (d, J = 262.5 Hz, 1F); HRMS (ESI) calcd for C₁₈H₁₇BrF₂O₂SNa⁺ [M+Na]⁺ 436.9993; found: 436.9986.



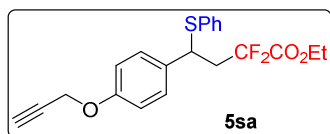
ethyl 2,2-difluoro-4-(perfluorophenyl)-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (62 mg, 73%). ¹H NMR (500 MHz, CDCl₃) δ 7.38-7.34 (m, 2H), 7.34-7.28 (m, 3H), 4.75 (dd, J = 9.9, 5.0 Hz, 1H), 4.35-4.21 (m, 2H), 3.08-2.75 (m, 2H), 1.33 (t, J = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.17 (t, J = 32.2 Hz), 145.85 (m), 143.9 (m), 141.66 (m), 139.50 (m), 138.38 (m), 136.40 (m), 133.87, 132.05, 129.36, 129.15, 114.43 (t, J = 252.4 Hz), 63.36, 37.82 (t, J = 23.1 Hz), 36.87 (m), 13.80; ¹⁹F NMR (471 MHz, CDCl₃) δ -104.11 (d, J = 264.4 Hz, 1F), -106.63 (d, J = 264.4 Hz, 1F), -154.51 (t, J = 20.9 Hz), -161.82 (td, J = 21.6, 7.4 Hz); HRMS (ESI) calcd for C₁₈H₁₃F₇O₂SNa⁺ [M+Na]⁺ 449.0417; found: 449.0418.



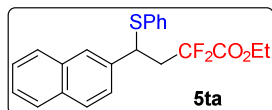
ethyl 4-(5-bromo-2-fluorophenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (52 mg, 60%). ¹H NMR (500 MHz, CDCl₃) δ 7.39-7.25 (m, 7H), 6.91-6.83 (m, 1H), 4.65 (t, J = 7.3 Hz, 1H), 4.22-4.06 (m, 2H), 2.86-2.72 (m, 2H), 1.29 (t, J = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.37 (t, J = 32.3 Hz), 159.16 (d, J = 248.7 Hz), 133.63, 132.36, 132.12 (d, J = 8.4 Hz), 131.89 (d, J = 3.5 Hz), 129.57 (d, J = 14.7 Hz), 129.14, 128.59, 117.39 (d, J = 24.1 Hz), 116.55 (d, J = 3.4 Hz), 114.52 (t, J = 252.4 Hz), 63.17, 39.48 (t, J = 23.8 Hz), 13.80; ¹⁹F NMR (471 MHz, CDCl₃) δ -104.19 (s, 1F), -119.06 (s, 1F); HRMS (ESI) calcd for C₁₈H₁₆BrF₃O₂SNa⁺ [M+Na]⁺ 454.9899; found: 454.9900.



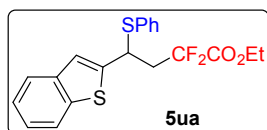
ethyl 4-(4-(allyloxy)phenyl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (33 mg, 42%). ^1H NMR (500 MHz, CDCl_3) δ 7.31-7.23 (m, 5H), 7.16-7.10 (m, 2H), 6.83-6.78 (m, 2H), 6.03 (ddt, $J = 17.2$, 10.5, 5.3 Hz, 1H), 5.40 (ddd, $J = 17.3$, 3.1, 1.6 Hz, 1H), 5.28 (ddd, $J = 10.5$, 2.7, 1.3 Hz, 1H), 4.50 (dt, $J = 5.3$, 1.5 Hz, 2H), 4.35 (dd, $J = 9.5$, 4.9 Hz, 1H), 3.97 (qq, $J = 10.7$, 7.2 Hz, 2H), 2.94-2.62 (m, 2H), 1.21 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.50 (t, $J = 32.2$ Hz), 158.11, 133.61, 133.11, 133.08, 131.60, 129.09, 128.97, 127.91, 117.75, 114.82 (t, $J = 252.0$ Hz), 114.57, 68.79, 62.86, 47.10-44.64 (m), 40.67 (t, $J = 23.7$ Hz), 13.72; ^{19}F NMR (471 MHz, CDCl_3) δ -102.13 (d, $J = 261.5$ Hz, 1F), -105.33 (d, $J = 261.5$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{21}\text{H}_{22}\text{F}_2\text{O}_3\text{SNa}^+ [\text{M}+\text{Na}]^+$ 415.1150; found: 415.1151.



ethyl 2,2-difluoro-4-(phenylthio)-4-(4-(prop-2-yn-1-yloxy)phenyl)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (43 mg, 55%). ^1H NMR (500 MHz, CDCl_3) δ 7.31-7.22 (m, 5H), 7.19-7.13 (m, 2H), 6.89-6.84 (m, 2H), 4.66 (d, $J = 2.4$ Hz, 2H), 4.35 (dd, $J = 9.5$, 4.9 Hz, 1H), 3.96 (qq, $J = 10.7$, 7.2 Hz, 2H), 2.93 – 2.60 (m, 2H), 2.51 (t, $J = 2.4$ Hz, 1H), 1.20 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.49 (t, $J = 32.5$ Hz), 163.23, 157.04, 133.51, 133.11, 132.44, 129.13, 129.00, 127.97, 114.79 (t, $J = 252.0$ Hz), 114.75, 78.40, 75.59, 62.90, 55.80, 48.44-44.64 (m), 40.65 (t, $J = 23.7$ Hz), 13.74; ^{19}F NMR (471 MHz, CDCl_3) δ -102.10 (d, $J = 261.7$ Hz, 1F), -105.35 (d, $J = 261.7$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{21}\text{H}_{20}\text{F}_2\text{O}_3\text{SNa}^+ [\text{M}+\text{Na}]^+$ 413.0993; found: 413.0995.

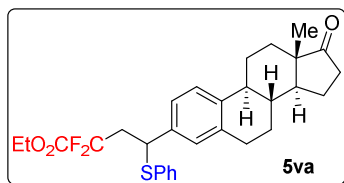


ethyl 2,2-difluoro-4-(naphthalen-2-yl)-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (46 mg, 60%), m.p. = 63.1-65.9 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.82-7.77 (m, 2H), 7.75-7.70 (m, 1H), 7.54 (s, 1H), 7.46 (tt, $J = 6.7$, 2.0 Hz, 3H), 7.32-7.27 (m, 2H), 7.25-7.19 (m, 3H), 4.54 (dd, $J = 9.2$, 5.2 Hz, 1H), 3.92- 3.73 (m, 2H), 3.06-2.71 (m, 2H), 1.09 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.51 (t, $J = 32.4$ Hz), 136.89, 133.34, 133.22, 132.97, 132.85, 129.00, 128.44, 128.06, 127.84, 127.60, 127.00, 126.30, 126.19, 125.54, 114.84 (t, $J = 252.8$ Hz), 62.86, 47.33-47.13 (m), 40.55 (t, $J = 23.8$ Hz), 13.55; ^{19}F NMR (471 MHz, CDCl_3) δ -102.21 (d, $J = 262.0$ Hz, 1F), -104.96 (d, $J = 262.0$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{22}\text{H}_{20}\text{F}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 409.1044; found: 409.1041.

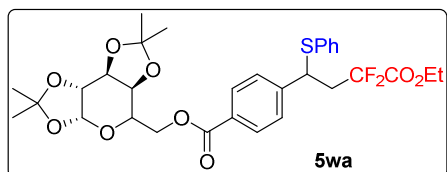


ethyl 4-(benzo[b]thiophen-2-yl)-2,2-difluoro-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 200:1. Pale yellow solid (53 mg, 67%), m.p. = 46.4-48.2 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.77 (dd, $J = 5.1$, 4.0 Hz, 1H), 7.64-7.57 (m, 1H), 7.39- 7.33 (m, 2H), 7.33-7.27 (m, 2H), 7.27-7.21 (m, 3H), 6.94 (s, 1H), 4.72 (dd, $J = 8.2$, 5.8 Hz, 1H), 4.02 (qq, $J = 10.7$, 7.2 Hz, 2H), 3.02-2.76 (m, 2H), 1.19 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126

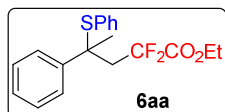
MHz, CDCl₃) δ 163.44 (t, J = 32.2 Hz), 144.99, 139.54, 138.99, 133.41, 132.83, 129.09, 128.45, 124.53, 124.40, 123.49, 122.75, 122.36, 114.59 (t, J = 251.9 Hz), 63.11, 43.30 (t, J = 5.1 Hz), 41.41 (t, J = 24.2 Hz), 13.67; ¹⁹F NMR (471 MHz, CDCl₃) δ -103.25 (d, J = 263.2 Hz, 1F), -104.56 (d, J = 263.4 Hz, 1F); HRMS (ESI) calcd for C₂₀H₁₈F₂O₂S₂Na⁺ [M+Na]⁺ 415.0608; found: 415.0607.



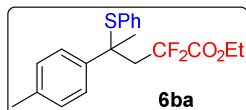
ethyl 2,2-difluoro-4-((8*R*,9*S*,13*S*,14*S*)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6*H*-cyclopenta[*a*]phenanthren-3-yl)-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 10:1. Colorless oil (74 mg, 72%). ¹H NMR (500 MHz, CDCl₃) δ 7.36-7.31 (m, 2H), 7.30-7.25 (m, 3H), 7.20 (dd, J = 8.1, 3.7 Hz, 1H), 7.03 (ddd, J = 10.4, 8.2, 1.8 Hz, 1H), 6.97-6.93 (m, 1H), 4.34 (dd, J = 9.1, 5.1 Hz, 1H), 4.05-3.89 (m, 2H), 2.96-2.63 (m, 4H), 2.51 (dd, J = 19.0, 8.5 Hz, 1H), 2.40 (dd, J = 10.0, 6.2 Hz, 1H), 2.25 (dd, J = 13.9, 7.3 Hz, 1H), 2.20-2.10 (m, 1H), 2.08-1.91 (m, 3H), 1.68-1.62 (m, 1H), 1.61-1.55 (m, 1H), 1.55-1.47 (m, 3H), 1.46-1.37 (m, 1H), 1.19 (td, J = 7.2, 2.0 Hz, 3H), 0.91 (s, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 220.76, 165.78 – 161.44 (m), 139.36, 136.88 (d, J = 8.1 Hz), 136.61 (d, J = 6.0 Hz), 133.95, 132.67, 129.01, 128.37 (d, J = 4.2 Hz), 127.79, 125.48 (d, J = 6.6 Hz), 125.14 (d, J = 3.7 Hz), 114.84 (t, J = 252 Hz), 62.82, 50.51, 47.96, 46.31 (t, J = 4.6 Hz), 44.35, 41.35-39.71 (m), 38.09, 35.86, 31.58, 29.30, 26.46, 25.67, 21.59, 13.86, 13.73; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.71 (ddd, J = 261.5, 51.0, 2.5 Hz, 1F), -104.73 (dd, J = 261.7, 36.3 Hz, 1F); HRMS (ESI) calcd for C₃₀H₃₄F₂O₃SNa⁺ [M+Na]⁺ 535.2089; found: 535.2089.



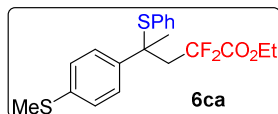
((3*aR*,5*aS*,8*aS*,8*bR*)-2,2,7,7-tetramethyltetrahydro-5*H*-bis([1,3]dioxolo)[4,5-*b*:4',5'-*d*]pyran-5-yl) methyl 4-(4-ethoxy-3,3-difluoro-4-oxo-1-(phenylthio)butyl)benzoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 30:1. Colorless oil (80 mg, 64%). ¹H NMR (500 MHz, CDCl₃) δ 7.93 (d, J = 8.3 Hz, 2H), 7.27-7.22 (m, 7H), 5.56 (d, J = 5.0 Hz, 1H), 4.65 (dd, J = 7.9, 2.5 Hz, 1H), 4.50 (ddd, J = 11.5, 4.8, 2.2 Hz, 1H), 4.40 (ddd, J = 10.5, 9.7, 7.1 Hz, 2H), 4.35 (dd, J = 5.0, 2.5 Hz, 1H), 4.31 (dd, J = 7.9, 1.8 Hz, 1H), 4.19-4.13 (m, 1H), 4.09-3.99 (m, 2H), 2.87-2.71 (m, 2H), 1.51 (s, 3H), 1.47 (s, 3H), 1.35 (s, 3H), 1.33 (s, 3H), 1.23 (t, J = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 165.96, 163.41 (t, J = 33.1 Hz), 145.34, 133.55, 132.65, 129.85, 129.38, 129.08, 128.38, 127.89, 114.65 (t, J = 250.9 Hz), 109.72, 108.81, 96.32, 71.14, 70.74, 70.53, 66.14, 64.00, 63.04, 46.84 (t, J = 4.4 Hz), 40.23 (t, J = 24.0 Hz), 26.03, 25.99, 24.99, 24.51, 13.74; ¹⁹F NMR (471 MHz, CDCl₃) δ -103.27 (dd, J = 262.5, 8.3 Hz, 1F), -104.21 (dd, J = 262.5, 3.5 Hz, 1F); HRMS (ESI) calcd for C₃₁H₃₆F₂O₉SNa⁺ [M+Na]⁺ 645.1940; found: 645.1941.



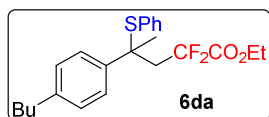
ethyl 2,2-difluoro-4-phenyl-4-(phenylthio)pentanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (43 mg, 61%). ^1H NMR (500 MHz, CDCl_3) δ 7.40 (dt, J = 3.1, 2.0 Hz, 2H), 7.35-7.31 (m, 1H), 7.31-7.27 (m, 2H), 7.25-7.21 (m, 3H), 7.20-7.17 (m, 2H), 3.90-3.62 (m, 2H), 3.30-3.09 (m, 1H), 2.72 (dd, J = 27.9, 14.5 Hz, 1H), 1.81 (s, 3H), 1.16 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.59 (t, J = 32.1 Hz), 142.00, 137.27, 131.03, 129.40, 128.57, 127.89, 127.29, 127.27, 115.057 (t, J = 252.0 Hz), 62.75, 51.15 (d, J = 6.3 Hz), 46.19-45.57 (m), 24.86 (d, J = 2.5 Hz), 13.63; ^{19}F NMR (471 MHz, CDCl_3) δ -95.41 (d, J = 260.2 Hz, 1F), -101.69 (d, J = 260.2 Hz, 1F); HRMS (ESI) calcd for $\text{C}_{19}\text{H}_{20}\text{F}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 373.1044; found: 373.1048.



ethyl 2,2-difluoro-4-(phenylthio)-4-(p-tolyl)pentanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (50 mg, 69%). ^1H NMR (500 MHz, CDCl_3) δ 7.37-7.31 (m, 1H), 7.31-7.27 (m, 2H), 7.26-7.21 (m, 4H), 7.10 (t, J = 8.0 Hz, 2H), 3.89-3.67 (m, 2H), 3.26-3.08 (m, 1H), 2.69 (dd, J = 28.1, 14.5 Hz, 1H), 2.32 (s, 3H), 1.78 (s, 3H), 1.16 (dd, J = 9.0, 5.4 Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.63 (t, J = 32.3 Hz), 138.99, 137.25, 136.94, 131.29, 129.32, 128.57, 127.14, 117.12 (t, J = 252.0 Hz), 62.71, 50.99 (d, J = 6.1 Hz), 47.23-44.40 (m), 24.96 (d, J = 2.6 Hz), 20.98, 13.59; ^{19}F NMR (471 MHz, CDCl_3) δ -95.54 (d, J = 260.2 Hz, 1F), -101.78 (d, J = 260.2 Hz, 1F); HRMS (ESI) calcd for $\text{C}_{20}\text{H}_{22}\text{F}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 387.1201; found: 387.1204.

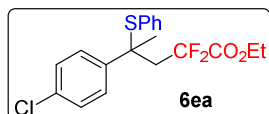


ethyl 2,2-difluoro-4-(4-(methylthio)phenyl)-4-(phenylthio)pentanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (50 mg, 63%), m.p. = 42.8-45.0 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.37-7.28 (m, 3H), 7.26-7.19 (m, 4H), 7.17-7.13 (m, 2H), 3.90-3.71 (m, 2H), 3.13 (dt, J = 22.4, 14.4 Hz, 1H), 2.70 (dt, J = 28.1, 14.1 Hz, 1H), 2.47 (s, 3H), 1.78 (s, 3H), 1.18 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.61 (t, J = 32.8 Hz), 138.84, 137.61, 137.25, 130.99, 129.43, 128.63, 127.75, 125.68, 115.02 (t, J = 253.3 Hz), 62.84, 50.93 (d, J = 5.9 Hz), 45.85 (t, J = 22.7 Hz), 24.88, 15.62, 13.64; ^{19}F NMR (471 MHz, CDCl_3) δ -95.74 (d, J = 260.5 Hz, 1F), -101.71 (d, J = 260.5 Hz, 1F); HRMS (ESI) calcd for $\text{C}_{20}\text{H}_{22}\text{F}_2\text{O}_2\text{S}_2\text{Na}^+ [\text{M}+\text{Na}]^+$ 419.0921; found: 419.0928.

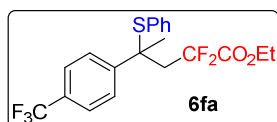


ethyl 4-(4-butylphenyl)-2,2-difluoro-4-(phenylthio)pentanoate. Eluent for flash column chromatography: petroleum ether. Colorless oil (51 mg, 63%). ^1H NMR (500 MHz, CDCl_3) δ 7.35-7.31 (m, 1H), 7.30-7.27 (m, 2H), 7.24-7.17 (m, 4H), 7.09 (d, J = 8.4 Hz, 2H), 3.76 (dq, J = 10.7, 7.2 Hz, 1H), 3.67 (dq, J = 10.7, 7.2 Hz, 1H), 3.18 (ddd, J = 24.0, 14.7, 12.9 Hz, 1H), 2.69 (dd, J = 27.9, 14.1 Hz, 1H), 2.61-2.55 (m, 2H), 1.79 (s, 3H), 1.60-1.55 (m, 3H), 1.34 (dt, J = 10.0,

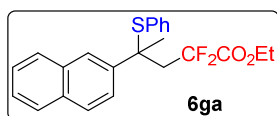
6.3 Hz, 2H), 1.15 (t, $J = 7.2$ Hz, 3H), 0.93 (dd, $J = 9.3, 5.4$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.59 (t, $J = 32.1$ Hz), 141.96, 139.04, 137.29, 131.26, 129.30, 128.51, 127.90, 127.15, 115.11 (t, $J = 252.0$ Hz), 62.66, 51.05 (d, $J = 6.8$ Hz), 46.60-45.22 (m), 35.11, 33.53, 24.90, 22.27, 13.96, 13.62; ^{19}F NMR (471 MHz, CDCl_3) δ -95.22 (d, $J = 259.9$ Hz, 1F), -101.72 (d, $J = 259.9$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{23}\text{H}_{28}\text{F}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 429.1670; found: 429.1667.



ethyl 4-(4-chlorophenyl)-2,2-difluoro-4-(phenylthio)pentanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (55 mg, 72%). ^1H NMR (500 MHz, CDCl_3) δ 7.38-7.29 (m, 3H), 7.28-7.22 (m, 4H), 7.20-7.16 (m, 2H), 4.00-3.77 (m, 2H), 3.12 (dt, $J = 20.9, 15.0$ Hz, 1H), 2.72 (td, $J = 15.1, 13.4$ Hz, 1H), 1.79 (s, 3H), 1.20 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.59 (t, $J = 32.2$ Hz), 140.90, 137.26, 133.06, 130.61, 129.60, 128.72, 127.95, 114.95 (t, $J = 252.0$ Hz), 62.94, 50.74 (d, $J = 5.3$ Hz), 45.73 (t, $J = 22.7$ Hz), 24.92, 13.68; ^{19}F NMR (471 MHz, CDCl_3) δ -96.24 (d, $J = 261.1$ Hz, 1F), -101.60 (d, $J = 261.1$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{19}\text{H}_{19}\text{ClF}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 407.066; found: 407.0651.

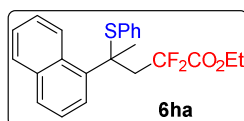


ethyl 2,2-difluoro-4-(phenylthio)-4-(4-(trifluoromethyl)phenyl)pentanoate. Eluent for flash column chromatography: petroleum ether. White solid (54 mg, 64%), m.p. = 53.4-55.4 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.51 (dd, $J = 24.3, 8.5$ Hz, 4H), 7.38-7.32 (m, 1H), 7.25-7.20 (m, 2H), 7.15 (dt, $J = 8.3, 1.6$ Hz, 2H), 3.95-3.76 (m, 2H), 3.16 (dt, $J = 19.6, 15.5$ Hz, 1H), 2.76 (td, $J = 15.4, 13.3$ Hz, 1H), 1.84 (s, 3H), 1.18 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.56 (t, $J = 32.2$ Hz), 146.54, 137.26, 130.31, 129.74, 129.30 (q, $J = 32.7$ Hz), 128.75, 127.60, 124.78 (q, $J = 3.7$ Hz), 124.00 (q, $J = 272.1$ Hz), 114.88 (t, $J = 252.0$ Hz), 62.94, 50.85 (d, $J = 4.7$ Hz), 45.52 (t, $J = 23.3$ Hz), 24.82, 13.63; ^{19}F NMR (471 MHz, CDCl_3) δ -62.64 (s, 3F), -96.65 (d, $J = 261.6$ Hz, 1F), -101.34 (d, $J = 261.7$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{20}\text{H}_{19}\text{F}_5\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 441.0918; found: 441.0920.

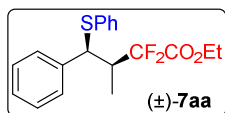


ethyl 2,2-difluoro-4-(naphthalen-2-yl)-4-(phenylthio)pentanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (52 mg, 65%), m.p. = 73.3-75.9 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.82 (t, $J = 8.8$ Hz, 2H), 7.74 (ddd, $J = 14.7, 8.1, 3.9$ Hz, 2H), 7.58 (s, 1H), 7.52-7.42 (m, 2H), 7.29 (dq, $J = 5.2, 3.5$ Hz, 1H), 7.17 (dd, $J = 9.7, 3.7$ Hz, 4H), 3.62 – 3.45 (m, 2H), 3.29 (dt, $J = 22.8, 14.2$ Hz, 1H), 2.81 (dd, $J = 28.2, 14.4$ Hz, 1H), 1.93 (s, 3H), 1.00 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.58 (t, $J = 32.1$ Hz), 139.36, 137.17, 132.64, 132.33, 130.91, 129.39, 128.58, 128.26, 127.58, 127.30, 126.32, 126.19, 125.99, 125.72, 115.15 (t, $J = 250.3$ Hz), 62.70, 51.50 (d, $J = 6.1$ Hz), 48.44-42.92 (m), 24.98, 13.40; ^{19}F NMR (471 MHz, CDCl_3) δ -95.29 (d, $J = 260.6$ Hz, 1F), -101.57 (d, $J = 260.6$ Hz, 1F); HRMS

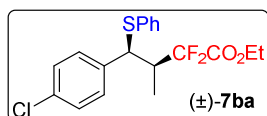
(ESI) calcd for $C_{23}H_{22}F_2O_2SNa^+$ $[M+Na]^+$ 423.1201; found: 423.1202.



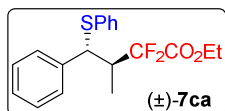
ethyl 2,2-difluoro-4-(naphthalen-1-yl)-4-(phenylthio)pentanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (45 mg, 56%), m.p. = 63.7-67.1 °C. 1H NMR (500 MHz, $CDCl_3$) δ 9.17 (d, J = 8.8 Hz, 1H), 7.89 (dd, J = 8.1, 1.2 Hz, 1H), 7.78 (d, J = 7.9 Hz, 1H), 7.63 (ddd, J = 8.6, 6.8, 1.5 Hz, 1H), 7.58-7.48 (m, 1H), 7.30 (t, J = 7.7 Hz, 1H), 7.27-7.23 (m, 2H), 7.17-7.10 (m, 2H), 7.06 (dd, J = 8.1, 1.2 Hz, 2H), 3.94-3.78 (m, 1H), 3.57 (dq, J = 10.7, 7.2 Hz, 1H), 3.00 (dq, J = 10.7, 7.2 Hz, 1H), 2.95-2.84 (m, 1H), 1.96 (s, 3H), 0.82 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.36-162.70 (m), 136.96, 136.36, 134.84, 131.23, 131.05, 129.61, 129.50, 129.21, 128.43, 127.49, 126.93, 125.29, 125.14, 124.64, 115.15 (t, J = 250.0 Hz), 62.44, 51.83 (d, J = 7.4 Hz), 48.81-41.88 (m), 29.14 (d, J = 4.1 Hz), 13.23; ^{19}F NMR (471 MHz, $CDCl_3$) δ -94.09 (d, J = 260.6 Hz, 1F), -101.74 (d, J = 260.7 Hz, 1F); HRMS (ESI) calcd for $C_{23}H_{22}F_2O_2SNa^+$ $[M+Na]^+$ 423.1201; found: 423.1201.



(±)-syn-ethyl 2,2-difluoro-3-methyl-4-phenyl-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (35 mg, 50%). 1H NMR (500 MHz, $CDCl_3$) δ 7.31 (d, J = 7.3 Hz, 2H), 7.24 (t, J = 7.4 Hz, 2H), 7.17 (dddd, J = 9.9, 7.0, 3.4, 1.9 Hz, 6H), 4.39 (d, J = 6.1 Hz, 1H), 4.14-3.96 (m, 2H), 3.00-2.81 (m, 1H), 1.36 (d, J = 7.1 Hz, 3H), 1.24 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.73 (t, J = 32.7 Hz), 140.53, 134.27, 132.07, 128.74, 128.60, 128.20, 127.41, 127.18, 118.60-114.23 (m), 62.83, 53.82 (t, J = 3.4 Hz), 44.97 (t, J = 22.1 Hz), 13.75, 10.23 (dd, J = 5.6, 3.7 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -105.49 (d, J = 258.1 Hz, 1F), -111.15 (d, J = 258.0 Hz, 1F); HRMS (ESI) calcd for $C_{19}H_{20}F_2O_2SNa^+$ $[M+Na]^+$ 373.1044; found: 373.1045.

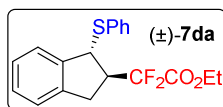


(±)-syn-ethyl 4-(4-chlorophenyl)-2,2-difluoro-3-methyl-4-(phenylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (50 mg, 65%), m.p. = 41.6-44.3 °C. 1H NMR (500 MHz, $CDCl_3$) δ 7.25-7.18 (m, 4H), 7.16 (s, 5H), 4.38-4.30 (m, 1H), 4.10 (qq, J = 10.8, 7.2 Hz, 2H), 2.92-2.76 (m, 1H), 1.39-1.32 (m, 3H), 1.26 (t, J = 7.2 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.66 (t, J = 32.5 Hz), 139.19, 133.69, 133.10, 132.39, 129.95, 128.87, 128.32, 127.52, 116.30 (t, J = 255.8 Hz), 62.94, 53.45, 44.71 (t, J = 22.1 Hz), 13.76, 10.53-10.30 (m); ^{19}F NMR (471 MHz, $CDCl_3$) δ -105.99 (d, J = 259.0 Hz, 1F), -110.37 (d, J = 258.9 Hz, 1F); HRMS (ESI) calcd for $C_{19}H_{19}ClF_2O_2SNa^+$ $[M+Na]^+$ 407.0655; found: 407.0657.

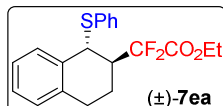


(±)-anti-ethyl 2,2-difluoro-3-methyl-4-phenyl-4-(phenylthio)butanoate. Eluent for flash column

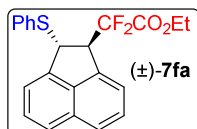
chromatography: petroleum ether. Colorless oil (30 mg, 43%). ^1H NMR (500 MHz, CDCl_3) δ 7.32 (d, $J = 7.5$ Hz, 2H), 7.24 (d, $J = 7.3$ Hz, 2H), 7.21 – 7.12 (m, 6H), 4.40 (d, $J = 5.9$ Hz, 1H), 4.15 – 3.98 (m, 2H), 2.99 – 2.80 (m, 1H), 1.37 (d, $J = 7.0$ Hz, 3H), 1.24 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.73 (t, $J = 32.7$ Hz), 140.57, 134.30, 132.08, 128.73, 128.60, 128.20, 127.40, 127.18, 116.41 (t, $J = 254.5$ Hz), 62.81, 53.85, 44.97 (t, $J = 22.2$ Hz), 13.74, 11.16 – 8.54 (m); ^{19}F NMR (471 MHz, CDCl_3) δ -105.49 (d, $J = 258.3$ Hz, 1F), -111.06 (d, $J = 258.1$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{19}\text{H}_{21}\text{F}_2\text{O}_2\text{S}^+ [\text{M}+\text{H}]^+$ 351.1225; found: 351.1219.



(±)-anti-ethyl 2,2-difluoro-2-(1-(phenylthio)-2,3-dihydro-1H-inden-2-yl)acetate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (41 mg, 59%). ^1H NMR (500 MHz, CDCl_3) δ 7.38-7.32 (m, 3H), 7.29-7.24 (m, 3H), 7.24-7.19 (m, 2H), 7.17-7.12 (m, 1H), 4.83 (d, $J = 4.4$ Hz, 1H), 4.18-4.04 (m, 2H), 3.27-3.14 (m, 1H), 3.07 (d, $J = 6.8$ Hz, 2H), 1.22 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.66 (t, $J = 32.6$ Hz), 141.39, 140.69, 133.23, 133.17, 128.97, 128.25, 127.96, 127.24, 125.16, 124.51, 119.35-110.03 (m), 63.08, 51.73 (t, $J = 4.1$ Hz), 49.92 (t, $J = 22.9$ Hz), 31.01 (t, $J = 4.0$ Hz), 13.77; ^{19}F NMR (471 MHz, CDCl_3) δ -109.29 (d, $J = 252.0$ Hz, 1F), -111.95 (d, $J = 252.0$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{19}\text{H}_{18}\text{F}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 371.0888; found: 371.0887.

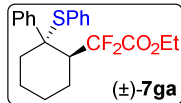


(±)-anti-ethyl 2,2-difluoro-2-(1-(phenylthio)-1,2,3,4-tetrahydronaphthalen-2-yl)acetate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (54 mg, 74%), m.p. = 63.6-66.3 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.35-7.26 (m, 6H), 7.18-7.10 (m, 2H), 7.08-7.01 (m, 1H), 4.63 (d, $J = 3.4$ Hz, 1H), 4.25 (dq, $J = 10.7, 7.2$ Hz, 1H), 4.16 (dq, $J = 10.8, 7.2$ Hz, 1H), 2.94 – 2.72 (m, 2H), 2.57 (dt, $J = 16.3, 6.2$ Hz, 1H), 2.35 (qd, $J = 10.6, 5.3$ Hz, 1H), 1.77 (td, $J = 12.7, 7.0$ Hz, 1H), 1.28 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 164.00 (t, $J = 32.6$ Hz), 137.61, 134.27, 133.59, 133.49, 130.32, 129.01, 128.38, 128.16, 127.14, 126.13, 116.67 (t, $J = 254.5$ Hz), 63.01, 45.34, 43.13 (t, $J = 22.0$ Hz), 26.01, 19.56 (d, $J = 3.7$ Hz), 13.85; ^{19}F NMR (471 MHz, CDCl_3) δ -109.85 (d, $J = 252.3$ Hz, 1F), -110.49 (d, $J = 252.3$ Hz, 1F); HRMS (ESI) calcd for $\text{C}_{20}\text{H}_{20}\text{F}_2\text{O}_2\text{SNa}^+ [\text{M}+\text{Na}]^+$ 385.1044; found: 385.1045.

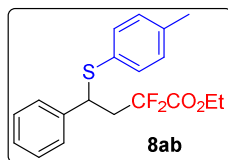


(±)-anti-ethyl 2,2-difluoro-2-(2-(phenylthio)-1,2-dihydroacenaphthylen-1-yl)acetate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Yellow solid (36 mg, 47%), m.p. = 47.3-50.8 °C. ^1H NMR (500 MHz, CDCl_3) δ 7.76-7.68 (m, 2H), 7.49 (tdd, $J = 12.3, 9.1, 3.3$ Hz, 2H), 7.40 (dt, $J = 4.0, 2.6$ Hz, 3H), 7.36 (d, $J = 7.0$ Hz, 1H), 7.26-7.21 (m, 3H), 5.28 (d, $J = 2.7$ Hz, 1H), 4.52-4.35 (m, 1H), 4.19-4.02 (m, 2H), 1.05 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, CDCl_3) δ 163.19 (t, $J = 32.4$ Hz), 142.53, 137.90, 135.98, 135.96, 135.94, 133.73, 132.62, 131.17, 128.95, 128.29, 128.18, 128.00, 124.94, 124.39, 122.05, 120.80, 115.38 (t, $J = 254.6$ Hz), 63.01, 56.78 (t, $J = 23.5$ Hz), 50.63 (t, $J = 4.2$ Hz), 13.62; ^{19}F NMR (471 MHz, CDCl_3) δ -108.05 (d, $J =$

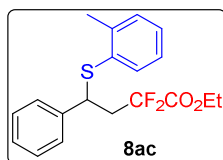
254.7 Hz, 1F), -109.46 (d, $J = 254.7$ Hz, 1F); HRMS (ESI) calcd for $C_{22}H_{18}F_2O_2SNa^+ [M+Na]^+$ 407.0888; found: 407.0889.



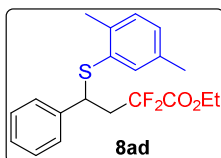
(±)-*anti*-(ethyl 2,2-difluoro-2-(2-phenyl-2-(phenylthio)cyclohexyl)acetate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (44 mg, 56%), m.p. = 70.5-71.9 °C. 1H NMR (500 MHz, $CDCl_3$) δ 7.67-7.29 (m, 2H), 7.23 (t, $J = 7.4$ Hz, 2H), 7.20-7.14 (m, 2H), 7.08-6.98 (m, 2H), 6.84 (dt, $J = 8.3, 1.5$ Hz, 2H), 3.91 (dq, $J = 10.7, 7.2$ Hz, 1H), 3.78 (dq, $J = 10.7, 7.2$ Hz, 1H), 3.35 (dt, $J = 27.2, 6.0$ Hz, 1H), 2.56-2.24 (m, 3H), 2.13 (d, $J = 14.8$ Hz, 1H), 1.76 (dd, $J = 17.7, 7.9$ Hz, 2H), 1.68-1.58 (m, 2H), 1.18 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.91 (t, $J = 32.8$ Hz), 142.97, 136.18, 130.83, 129.34, 128.76, 128.18, 127.28, 127.05, 117.03 (dd, $J = 264.9, 251.4$ Hz), 62.61, 58.14, 45.81 (dd, $J = 21.2, 18.5$ Hz), 28.25 (d, $J = 5.3$ Hz), 22.02 (d, $J = 8.9$ Hz), 21.20, 21.01, 13.61; ^{19}F NMR (471 MHz, $CDCl_3$) δ -95.62 (d, $J = 264.8$ Hz, 1F), -102.85 (d, $J = 264.7$ Hz, 1F); HRMS (ESI) calcd for $C_{22}H_{24}F_2O_2SNa^+ [M+Na]^+$ 413.1357; found: 413.1352.



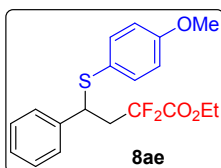
ethyl 2,2-difluoro-4-phenyl-4-(*p*-tolylthio)butanoate Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (37 mg, 53%), m.p. = 35.7-37.9 °C. 1H NMR (500 MHz, $CDCl_3$) δ 7.29-7.17 (m, 7H), 7.06 (d, $J = 8.0$ Hz, 2H), 4.29 (dd, $J = 9.3, 5.1$ Hz, 1H), 3.95 (dddd, $J = 17.9, 10.7, 7.2, 3.6$ Hz, 2H), 2.93-2.63 (m, 2H), 2.31 (s, 3H), 1.20 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.52 (t, $J = 32.3$ Hz), 139.77, 138.33, 133.72, 129.76, 129.66, 128.39, 127.97, 127.73, 114.83 (t, $J = 252.9$ Hz), 62.84, 47.55 – 46.88 (m), 40.48 (t, $J = 23.7$ Hz), 21.17, 13.70; ^{19}F NMR (471 MHz, $CDCl_3$) δ -102.26 (d, $J = 261.3$ Hz, 1F), -105.07 (d, $J = 261.4$ Hz, 1F); HRMS (ESI) calcd for $C_{19}H_{20}F_2O_2SNa^+ [M+Na]^+$ 373.1044; found: 373.1049.



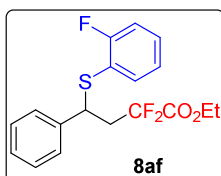
ethyl 2,2-difluoro-4-phenyl-4-(*o*-tolylthio)butanoate Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (45 mg, 64%). 1H NMR (500 MHz, $CDCl_3$) δ 7.31 (d, $J = 7.7$ Hz, 1H), 7.28-7.20 (m, 5H), 7.18-7.15 (m, 2H), 7.11 (td, $J = 8.6, 3.7$ Hz, 1H), 4.32 (dd, $J = 9.4, 4.9$ Hz, 1H), 4.01-3.86 (m, 2H), 2.98-2.67 (m, 2H), 2.30 (s, 3H), 1.20 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.49 (t, $J = 32.4$ Hz), 140.84, 139.66, 133.61, 132.76, 130.44, 128.42, 128.10, 127.89, 127.82, 126.50, 114.81 (t, $J = 252.2$ Hz), 62.87, 47.36-44.69 (m), 40.52 (t, $J = 23.7$ Hz), 20.59, 13.71; ^{19}F NMR (471 MHz, $CDCl_3$) δ -102.26 (d, $J = 261.9$ Hz, 1F), -105.03 (d, $J = 261.9$ Hz, 1F); HRMS (ESI) calcd for $C_{19}H_{20}F_2O_2SNa^+ [M+Na]^+$ 373.1044; found: 373.1045.



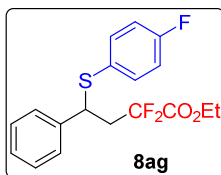
ethyl 4-((2,5-dimethylphenyl)thio)-2,2-difluoro-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. Colorless oil (55 mg, 76%). ¹H NMR (500 MHz, CDCl₃) δ 7.27-7.22 (m, 2H), 7.12 (d, *J* = 1.5 Hz, 1H), 7.05 (d, *J* = 7.7 Hz, 1H), 6.97 (dd, *J* = 7.6, 1.6 Hz, 1H), 4.30 (dd, *J* = 9.6, 4.7 Hz, 1H), 4.01-3.85 (m, 1H), 2.82 (dddd, *J* = 19.6, 17.8, 14.9, 12.4, 7.2 Hz, 1H), 2.25 (s, 2H), 1.19 (t, *J* = 7.2 Hz, 1H); ¹³C NMR (126 MHz, CDCl₃) δ 163.50 (t, *J* = 32.5 Hz), 139.65, 137.65, 136.03, 134.27, 132.33, 130.23, 128.93, 128.38, 127.94, 127.79, 114.83 (t, *J* = 252.0 Hz), 62.84, 46.29-46.00 (m), 40.46 (t, *J* = 23.6 Hz), 20.76, 20.08, 13.69; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.11 (d, *J* = 261.6 Hz, 1F), -105.23 (d, *J* = 261.6 Hz, 1F); HRMS (ESI) calcd for C₂₀H₂₂F₂O₂SNa⁺ [M+Na]⁺ 387.1201; found: 387.1204.



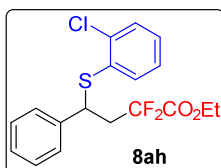
ethyl 2,2-difluoro-4-((4-methoxyphenyl)thio)-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (53 mg, 72%), m.p. = 42.3-45.4 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.28-7.22 (m, 3H), 7.22-7.18 (m, 2H), 7.17-7.13 (m, 2H), 6.80-6.75 (m, 2H), 4.19 (dd, *J* = 9.1, 5.3 Hz, 1H), 4.04-3.88 (m, 2H), 3.79 (d, *J* = 9.6 Hz, 3H), 2.90-2.62 (m, 2H), 1.20 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.57 (t, *J* = 32.4 Hz), 160.08, 139.88, 136.40, 128.33, 127.97, 127.66, 123.52, 114.88 (t, *J* = 251.4 Hz), 114.47, 62.84, 55.30, 49.79-44.71 (m), 40.25 (t, *J* = 23.8 Hz), 13.71; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.33 (d, *J* = 261.0 Hz, 1F), -104.91 (d, *J* = 261.0 Hz, 1F); HRMS (ESI) calcd for C₁₉H₂₀F₂O₃SNa⁺ [M+Na]⁺ 389.0993; found: 389.0998.



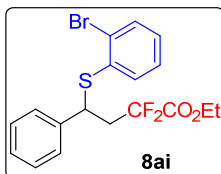
ethyl 2,2-difluoro-4-((2-fluorophenyl)thio)-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (54 mg, 76%), m.p. = 42.4-43.6 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.30-7.18 (m, 7H), 7.07-6.97 (m, 2H), 4.50 (dd, *J* = 9.9, 4.5 Hz, 1H), 3.94 (qq, *J* = 10.7, 7.2 Hz, 2H), 2.89 (dddd, *J* = 19.2, 14.8, 12.1, 9.9 Hz, 1H), 2.77-2.61 (m, 1H), 1.19 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.88-162.81 (m), 162.67 (d, *J* = 246.9 Hz), 139.11, 135.75 (d, *J* = 0.7 Hz), 130.52 (d, *J* = 8.0 Hz), 128.41, 127.94, 124.46 (d, *J* = 3.8 Hz), 120.28 (d, *J* = 18.1 Hz), 115.88 (d, *J* = 23.0 Hz), 114.69 (t, *J* = 252.0 Hz), 62.89, 47.01-43.57 (m), 40.56 (t, *J* = 23.7 Hz), 13.68; ¹⁹F NMR (471 MHz, CDCl₃) δ -101.88 (d, *J* = 262.0 Hz, 1F), -105.33 (d, *J* = 262.1 Hz, 1F), -107.28 (s, 1F); HRMS (ESI) calcd for C₁₈H₁₇F₃O₂SNa⁺ [M+Na]⁺ 377.0794; found: 377.0796.



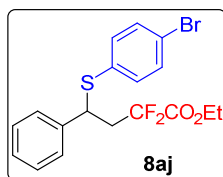
ethyl 2,2-difluoro-4-((4-fluorophenyl)thio)-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (49 mg, 69%), m.p. = 71.2-73.0 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.28-7.20 (m, 5H), 7.17-7.13 (m, 2H), 6.95-6.89 (m, 2H), 4.26 (dd, *J* = 8.9, 5.5 Hz, 1H), 4.05-3.88 (m, 2H), 2.93-2.63 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.49 (t, *J* = 32.3 Hz), 162.94 (d, *J* = 248.9 Hz), 139.60, 136.29 (d, *J* = 8.4 Hz), 128.42, 128.22 (d, *J* = 3.3 Hz), 127.93, 127.84, 116.06 (d, *J* = 21.8 Hz), 114.77 (t, *J* = 251.6 Hz), 62.92, 47.70 (t, *J* = 4.5 Hz), 40.30 (t, *J* = 23.9 Hz), 13.71; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.49 (d, *J* = 261.7 Hz, 1F), -104.87 (d, *J* = 261.8 Hz, 1F), -112.55 (s, 1F); HRMS (ESI) calcd for C₁₈H₁₇F₃O₂SNa⁺ [M+Na]⁺ 377.0794; found: 377.0791.



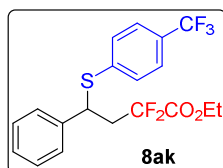
ethyl 4-((2-chlorophenyl)thio)-2,2-difluoro-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (62 mg, 84%), m.p. = 48.7-50.7 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.38 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.32-7.24 (m, 5H), 7.24- 7.20 (m, 1H), 7.17 (td, *J* = 7.6, 1.8 Hz, 1H), 7.12 (td, *J* = 7.5, 1.5 Hz, 1H), 4.57 (dd, *J* = 9.8, 4.4 Hz, 1H), 4.04-3.84 (m, 2H), 2.91 (dddd, *J* = 19.1, 14.9, 12.2, 9.9 Hz, 1H), 2.80-2.64 (m, 1H), 1.19 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 165.50-160.34 (m), 138.90, 136.80, 133.68, 132.78, 130.00, 128.88, 128.52, 128.02, 127.99, 127.17, 119.00-109.35 (m), 62.93, 46.63-43.19 (m), 40.54 (t, *J* = 23.7 Hz), 13.70; ¹⁹F NMR (471 MHz, CDCl₃) δ -101.91 (d, *J* = 262.5 Hz, 1F), -105.26 (d, *J* = 262.6 Hz, 1F); HRMS (ESI) calcd for C₁₈H₁₇F₂ClO₂SNa⁺ [M+Na]⁺ 393.0498; found: 393.0501.



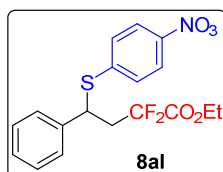
ethyl 4-((2-bromophenyl)thio)-2,2-difluoro-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (63 mg, 76%), m.p. = 40.9-41.8 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.57 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.35-7.25 (m, 5H), 7.23 (ddd, *J* = 7.0, 3.7, 1.5 Hz, 1H), 7.18 (td, *J* = 7.6, 1.4 Hz, 1H), 7.11-7.05 (m, 1H), 4.58 (dd, *J* = 9.8, 4.4 Hz, 1H), 4.04-3.84 (m, 2H), 2.92 (dddd, *J* = 19.1, 14.9, 12.2, 9.9 Hz, 1H), 2.83-2.66 (m, 1H), 1.19 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.35 (t, *J* = 32.3 Hz), 138.80, 134.93, 133.33, 133.22, 128.84, 128.55, 128.05, 128.03, 127.83, 127.20, 118.68-110.03 (m), 62.94, 45.45 (dd, *J* = 5.6, 3.7 Hz), 40.47 (t, *J* = 23.8 Hz), 13.71; ¹⁹F NMR (471 MHz, CDCl₃) δ -101.90 (d, *J* = 262.6 Hz, 1F), -105.25 (d, *J* = 262.6 Hz, 1F); HRMS (ESI) calcd for C₁₈H₁₇F₂BrO₂SNa⁺ [M+Na]⁺ 436.9993; found: 436.9996.



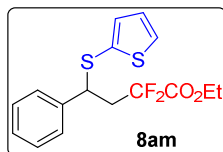
ethyl 4-((4-bromophenyl)thio)-2,2-difluoro-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (64 mg, 78%), m.p. = 58.0-60.6 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.38-7.33 (m, 2H), 7.30-7.22 (m, 3H), 7.20 (ddd, *J* = 6.6, 3.7, 1.5 Hz, 2H), 7.15-7.09 (m, 2H), 4.34 (dd, *J* = 9.0, 5.3 Hz, 1H), 3.98 (qq, *J* = 10.8, 7.2 Hz, 2H), 2.91-2.65 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.43 (t, *J* = 32.3 Hz), 139.41, 134.72, 132.50, 132.08, 128.52, 127.97, 127.92, 122.43, 118.60-110.18 (m), 62.94, 49.16-45.61 (m), 40.48 (t, *J* = 23.8 Hz), 13.72; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.46 (d, *J* = 262.3 Hz, 1F), -104.95 (d, *J* = 262.5 Hz, 1F); HRMS (ESI) calcd for C₁₈H₁₇F₂BrO₂SNa⁺ [M+Na]⁺ 436.9993; found: 436.9992.



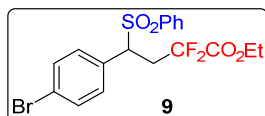
ethyl 2,2-difluoro-4-phenyl-4-((4-(trifluoromethyl)phenyl)thio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 100:1. White solid (57 mg, 71%), m.p. = 49.5-52.0 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.48 (d, *J* = 8.2 Hz, 2H), 7.35 (d, *J* = 8.2 Hz, 2H), 7.32-7.23 (m, 5H), 4.51 (dd, *J* = 9.0, 5.2 Hz, 1H), 4.09-3.89 (m, 2H), 2.97-2.66 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.35 (t, *J* = 32.2 Hz), 139.07, 138.98, 131.31, 129.33 (q, *J* = 32.7 Hz), 128.67, 128.17, 127.89, 125.77 (q, *J* = 3.7 Hz), 123.92 (q, *J* = 272.1 Hz), 114.61 (t, *J* = 252.0 Hz), 63.00, 48.83-43.44 (m), 40.72 (t, *J* = 23.9 Hz), 13.71; ¹⁹F NMR (471 MHz, CDCl₃) δ -62.66 (s, 3F), -102.40 (d, *J* = 263.3 Hz, 1F), -105.10 (d, *J* = 263.3 Hz, 1F); HRMS (ESI) calcd for C₁₉H₁₇F₅O₂SNa⁺ [M+Na]⁺ 427.0762; found: 427.0768.



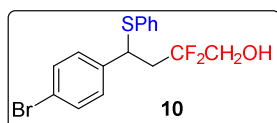
ethyl 2,2-difluoro-4-((4-(nitrooxy)phenyl)thio)-4-phenylbutanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 50:1. White solid (65 mg, 82%), m.p. = 81.8-84.0 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.11-8.03 (m, 2H), 7.38-7.23 (m, 7H), 4.63 (dd, *J* = 9.0, 5.2 Hz, 1H), 4.14-3.89 (m, 2H), 3.00-2.67 (m, 2H), 1.22 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.22 (t, *J* = 32.2 Hz), 138.58, 129.64, 128.85, 128.43, 127.87, 126.38, 124.46, 123.98, 114.48 (t, *J* = 252.2 Hz), 63.11, 48.44-43.96 (m), 40.83 (t, *J* = 23.8 Hz), 13.73; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.00, -102.57, -104.92, -105.48; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.29 (d, *J* = 264.5 Hz, 1F), -105.20 (d, *J* = 264.5 Hz, 1F); HRMS (ESI) calcd for C₁₈H₁₇F₂NO₅SNa⁺ [M+Na]⁺ 420.0688; found: 420.0689.



ethyl 2,2-difluoro-4-phenyl-4-(thiophen-2-ylthio)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 150:1. White solid (53 mg, 77%), m.p. = 44.3-45.9 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.36 (dd, *J* = 5.1, 1.5 Hz, 1H), 7.31-7.22 (m, 3H), 7.20-7.13 (m, 2H), 6.98-6.90 (m, 2H), 4.22 (dd, *J* = 9.1, 5.3 Hz, 1H), 4.05-3.91 (m, 2H), 2.95-2.70 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 163.48 (t, *J* = 32.4 Hz), 139.11, 136.27, 131.20, 131.02, 128.42, 127.98, 127.94, 127.61, 114.78 (t, *J* = 252.2 Hz), 62.91, 51.57-47.47 (m), 39.89 (t, *J* = 23.9 Hz), 13.72; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.23 (d, *J* = 261.2 Hz, 1F), -104.96 (d, *J* = 261.2 Hz, 1F); HRMS (ESI) calcd for C₁₆H₁₆F₂O₂S₂Na⁺ [M+Na]⁺ 365.0452; found: 365.0453.



ethyl 4-(4-bromophenyl)-2,2-difluoro-4-(phenylsulfonyl)butanoate. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 10:1. White solid (140 mg, 78%), m.p. = 145.2 - 147.2 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.62-7.57 (m, 1H), 7.56-7.51 (m, 2H), 7.45-7.40 (m, 2H), 7.36 (d, *J* = 8.6 Hz, 2H), 7.03-6.96 (m, 2H), 4.30 (dd, *J* = 11.3, 2.3 Hz, 1H), 4.09-3.97 (m, 2H), 3.23 (dddd, *J* = 17.5, 14.8, 12.3, 2.4 Hz, 1H), 2.96 (qd, *J* = 15.4, 11.4 Hz, 1H), 1.22 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (126 MHz, CDCl₃) δ 162.90 (t, *J* = 32.0 Hz), 135.91, 134.26, 131.68, 131.43, 130.14, 129.06, 129.04, 123.69, 116.85-111.97 (m), 64.79 (dd, *J* = 5.0, 2.2 Hz), 63.33, 33.96-32.12 (m), 13.74; ¹⁹F NMR (471 MHz, CDCl₃) δ -102.92 (d, *J* = 261.0 Hz, 1F), -105.10 (d, *J* = 261.0 Hz, 1F); HRMS (ESI) calcd for C₁₈H₁₇BrF₂O₄SN⁺ [M+Na]⁺ 468.9891; found: 468.9891.



4-(4-bromophenyl)-2,2-difluoro-4-(phenylthio)butan-1-ol. Eluent for flash column chromatography: petroleum ether: ethyl acetate = 20:1. Pale yellow oil (141 mg, 95%). ¹H NMR (500 MHz, CDCl₃) δ 7.41-7.36 (m, 2H), 7.30-7.22 (m, 5H), 7.14-7.08 (m, 2H), 4.41 (dd, *J* = 8.1, 6.0 Hz, 1H), 3.77-3.46 (m, 2H), 2.73-2.52 (m, 2H), 1.92 (s, 1H); ¹³C NMR (126 MHz, CDCl₃) δ 140.13, 133.21, 133.19, 131.60, 129.40, 129.02, 128.09, 122.03 (t, *J* = 244.0 Hz), 121.36, 64.03 (t, *J* = 31.8 Hz), 46.57 (t, *J* = 4.2 Hz), 39.18 (t, *J* = 24.0 Hz); ¹⁹F NMR (471 MHz, CDCl₃) δ -105.38 (s, 1F), -105.39 (s, 1F); HRMS (ESI) calcd for C₁₆H₁₄BrF₂O₂S⁻ [M-H]⁻ 370.9922; found: 370.9924.

8) References

(1) (a) Wang, W.; Peng, X.; Wei, F.; Tung, C.-H.; Xu, Z. *Angew. Chem.* **2016**, 128, 659. (b) Liang, G.; Liu, M.; Chen, J.; Ding, J.; Gao, W.; Wu, H. *Chin. J. Chem.* **2012**, 30, 1611.

9) NMR Spectra

