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Synthesis of Ψ[CH(R_F)NH]Gly-peptides: The dramatic effect of a single fluorine atom on the diastereocontrol of the key aza-Michael reaction

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ABSTRACT

We describe in full-detail the synthesis of new ψ[CH(R_F)NH]-peptidomimetics, having different fluoroalkyl groups R_F, as peptide bond surrogates. A key step in the synthesis is a stereoselective aza-Michael addition of chiral α-amino acid esters to β-fluoroalkyl-α-nitroethenes. The diastereoselection of the process was influenced by the electronegativity, rather than by the steric bulk, of the fluorinated residue R_F in the β-position of the nitroalkene acceptors. Replacement of a single F atom of R_F by a hydrogen or methyl group brings about a dramatic drop of stereocontrol, whereas Br, Cl and CF_3, albeit bulkier than F, provide inferior results in terms of stereocontrol. A mechanistic hypothesis is provided.

The main drawback in the use of peptides as drugs is represented by their low bioavailability and low metabolic stability. In order to circumvent this problem, while maintaining the excellent biological properties of peptidic structures, backbone modification is a popular and effective strategy. In medicinal chemistry and drug discovery, a viable and successful approach is the rational design of peptidomimetics in which a scissile peptide bond is replaced by a surrogate function [1]. This strategy is particularly efficient when: (1) the peptide bond surrogate is more stable to enzymatic hydrolysis than the native peptide bond [2]; (2) it is able to mimic either the original peptide bond or the transition state of amide bond hydrolysis at the substrate cleavage site [3]; (3) it influences the conformational preference of neighbouring residues; (4) by modifying the electronic properties, the peptide bond surrogate affects significantly the transport properties of the parent peptides [4].

Recently, we proposed the trifluoroethylamino unit [5] as a peptide bond replacement, and we described its incorporation into partially modified retro- (PMR) peptides **A** [6] and into native peptide chains **B** [7] (Fig. 1).

The trifluoroethylamine unit might be also seen as a hybrid between a peptide bond mimic and a proteolytic transition state analogue, as it combines some of the properties of a peptidyl –CONH– group (very low NH basicity, a CH(CF_3)–NH–CH backbone angle close to 120°, a C–CF_3 bond substantially isopolar with the C=O) with properties of the tetrahedral intermediate of the protease-mediated hydrolysis reaction of a peptide bond (high electron density on the CF_3 group, tetrahedral backbone carbon). Moreover, the presence of the bulky CF_3 group is probably the driving force for the high stability of the turn-like conformation of appropriately configured retro-peptides **A** both in low polarity organic solvent solutions and in solid state. Recently, this conceptually new peptide bond surrogate has found the first validations in drug discovery [8].

In order to gain a deeper understanding of the biomedicinal properties of these peptide mimics, and to investigate further the effect and the capacity of the fluorinated residue to induce and stabilize secondary structures in peptide mimics, we undertook a research program aimed at the synthesis of Ψ[CH(R_F)NH]Gly-peptides **1** (R = H) having different R_F fluoroalkyl groups, namely R_F = CF_2H, CF_2CH_3, CF_2Cl, CF_2Br, and C_2F_5. Moreover, following the same synthetic strategy used for the synthesis of Ψ[CH(CF_3)NH]Gly-peptides **B** (R_F = CF_3) from the nitroalkene **2** (Table 2) [7], we decided to investigate the role of the different fluorinated residues R_F on the diastereoselectivity of the key aza-Michael addition of α-amino acid esters **8** to β-fluoroalkyl-α-nitroethenes **3–7** (see Table 2) [9]. The various R_F groups differ from each other not only in terms of steric bulk (quantified here by means of the Bondi volumes) and shape, but

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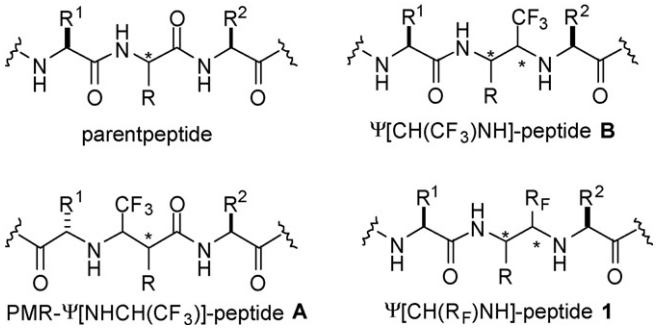
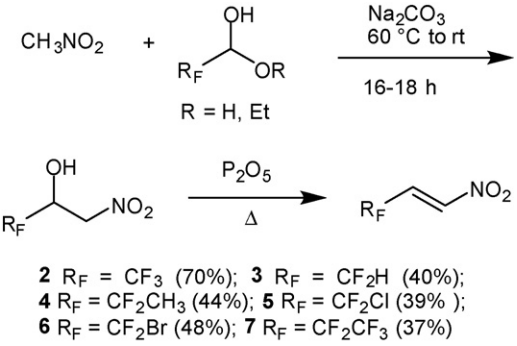


Fig. 1. Structure of Ψ[CH(R_F)NH]-peptides **1**.



Scheme 1. Synthesis of nitro-alkenes **2**–**7**.

Table 1
Empirical electronegativities and Bondi volumes for X substituents ($R_F = CF_2X$).

X substituent	Bondi volume ($cm^3\ mol^{-1}$)	Electronegativity
H	3.3	2.28
CH_3	13.7	2.30
F	5.8	3.95
Cl	12.0	3.03
Br	15.1	2.80
CF_3	21.3	3.35

also in terms of electronegativities (Table 1) [10]. More specifically, if one considers $R_F = CF_2$-X, then the difference between the six R_F groups studied herein depends on the X substituent. Thus, in terms of electronegativity, the CF_3 group (X = F) is the most electronegative R_F group, followed by C_2F_5 (X = CF_3), which in turn is more electronegative than CF_2Cl (X = Cl) and CF_2Br (X = Br). The CF_2CH_3 (X = CH_3) and CF_2H (X = H) groups occupy the last positions of the list. Sterically, the C_2F_5 group is the bulkiest, followed by CF_2Br, which in turn is only slightly bulkier than CF_2CH_3 and CF_2Cl, but remarkably bulkier than CF_3 (X = F) and CF_2H, respectively. One should also note that the CF_3 group is rotationally symmetrical around the axis of its C–C bond, in analogy with the CH_3 group, whereas the C_2F_5, CF_2Cl, CF_2Br and CF_2CH_3 groups do not feature such rotational symmetry. In terms of "effective bulk" the isotropic CF_3 is expected to occupy an even smaller volume than the anisotropic C_2F_5, CF_2Cl and CF_2Br [11]. Thus, if steric bulk were the dominating factor in the stereoselectivity of the aza-Michael reaction, one would expect a much higher diastereocontrol when R_F is a C_2F_5 or CF_2Br, rather than a CF_3.

β-Fluoroalkyl-α-nitroethenes **2**–**7**, having respectively $-CF_3$, $-CF_2H$, $-CF_2CH_3$, $-CF_2Cl$, $-CF_2Br$ and $-CF_2CF_3$ as R_F groups at the β position, were prepared in multigram amounts by reacting the corresponding aldehyde hydrates or hemiacetals with nitromethane and a catalytic amount of Na_2CO_3 affording β-nitro alcohol intermediates that were dehydrated by refluxing in the presence of P_2O_5 (Scheme 1) [12].

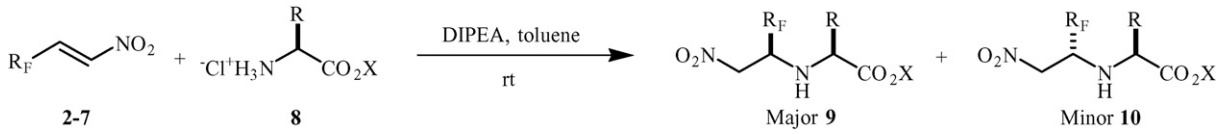
The aza-Michael reactions between nitroalkene acceptors **3**–**7** and α-aminoacid ester hydrochlorides **8a**–**d** were performed using the protocol previously optimized to achieve the best diastereoselectivity with **2** [7], namely using 1.1 equiv. of DIPEA (the first equiv. is needed to quench the hydrochloric acid of **8**) in toluene at rt, producing a mixture of *syn*-**9** (major diastereoisomer) and *anti*-**10** (minor diastereoisomer), which proved to be easily separable by simple flash chromatography (except for the CF_2H derivatives **9**, **10f**,**g** which could not be separated), in excellent overall yields (Table 2). The stereochemistry of the minor diastereoisomer **10z** (entry 25) was assessed by X-ray diffraction (Fig. 2) [13], whereas the configuration of the other adducts **9** and **10** were confidentially assigned on the basis of their spectroscopic features in comparison with those of **9z** and **10z** [14], except for the CF_2H compounds **9**, **10e**–**g** (entries 5–7) whose stereochemistry could not be unambiguously assigned.

In these conditions the diastereoselection of the process depends only on the nature of (1) the R amino acidic side chain of **8**, and (2) the fluorinated residue R_F on the nitroethene acceptors **2**–**7**. The results of the additions of **8a**–**d** to the trifluoro derivative **2** ($R_F = CF_3$) were previously published [7], and are summarized for the sake of comparison in entries 1–4 (Table 2).

When $R_F = CF_2H$ (nitroethene **3**) (entries 5–8, Table 2), which is both the least electronegative and the least bulky R_F group among those examined herein, a dramatic drop of diastereoselectivity was observed in comparison with **2** ($R_F = CF_3$). The additions of the α-amino esters **8a**–**d** to **4** ($R_F = CF_2CH_3$) (entries 9–12, Table 2) proved to be only slightly more diastereoselective than those obtained with **3** ($R_F = CF_2H$), and still much less diastereoselective than those with **2** ($R_F = CF_3$). Generally higher diastereoselectivities were observed with **5** ($R_F = CF_2Cl$) (entries 13–16, Table 2) as the Michael acceptor, but still slightly worse when compared to those achieved with **2** ($R_F = CF_3$). The results obtained with the nitroalkene **6** ($R_F = CF_2Br$) (entries 17–20, Table 2) were in all cases comparable with those of the nitroalkene **5** ($R_F = CF_2Cl$). Surprisingly, even the diastereoselectivity of the reactions performed with the nitroethene **7** ($R_F = C_2F_5$) (entries 21–24, Table 2), having the most sterically demanding R_F group (see Table 1), proved to be less stereoselective than the reactions involving **2** ($R_F = CF_3$), and very similar to those obtained with the nitroalkenes **5** and **6** ($R_F = CF_2Cl$ and CF_2Br, respectively).

The experimental results above suggest that the diastereoselectivity of the aza-Michael reaction is much more influenced by the electronegativity of the β-fluoroalkyl substituents R_F, rather than by their steric bulk. In fact, the dramatic drop of diastereocontrol observed with the nitroalkene **3** ($R_F = CF_2H$) and **4** ($R_F = CF_2CH_3$) as compared with that featured by **2** ($R_F = CF_3$) cannot be explained in terms of steric bulk, as the CF_2H group is quite close in size to the CF_3 (their Bondi volumes are, respectively, 18.8 $cm^3\ mol^{-1}$ vs. 21.3 $cm^3\ mol^{-1}$) while the CF_2CH_3 group is much bigger (Bondi volume = 29.2 $cm^3\ mol^{-1}$). Thus, the striking effect on the stereocontrol observed by replacing a single F atom of the nitroalkene **2** with an H atom in **3** and a CH_3 in **4**, must be ascribed to the considerably higher electronegativity of F with respect to H and CH_3. On the other hand, the CF_3 group is "smaller" than the CF_2Cl, CF_2Br and, in particular, the C_2F_5 groups (see Table 1 and discussion thereof), therefore the decreased stereoselectivities observed with nitroalkenes **5**–**7** as compared with the CF_3-nitroalkene **2**, cannot be explained as well in terms of steric bulk. One should therefore notice that, within the set of nitroalkenes **2**–**7**, the trend of stereoselectivity **2** > **7** ≈ **5** ≈ **6** > **4** > **3** in the aza-Michael reaction matches quite well the trend of electronegativity of the X group in R_F ($R_F = CF_2$-X) namely F > CF_3 > Cl > Br > CH_3 ≈ H.

Table 2
The aza-Michael reaction



Entry	Nitroethene	R_F	α-Aminoester	Major product	R	X	Ratio **9**:**10**[b]	Yield %[c]
1[a]	**2**	CF_3	L-**8a**	**9a**	Me (Ala)	*tert*-Bu	5.8:1.0	60
2[a]	**2**	CF_3	L-**8b**	**9b**	*sec*-Bu (Ile)	Me	7.5:1.0	75
3[a]	**2**	CF_3	L-**8c**	**9c**	Bn (Phe)	*tert*-Bu	8.5:1.0	60
4[a]	**2**	CF_3	L-**8d**	**9d**	*iso*-Pr (Val)	*tert*-Bu	11.7:1.0	65
5	**3**	CF_2H	L-**8a**	**9e**	Me (Ala)	*tert*-Bu	1.1:1.0[d]	77
6	**3**	CF_2H	L-**8b**	**9f**	*sec*-Bu (Ile)	Me	1.4:1.0[d,e]	96
7	**3**	CF_2H	L-**8c**	**9g**	Bn (Phe)	*tert*-Bu	1.7:1.0[d,e]	68
8	**3**	CF_2H	L-**8d**	**9h**	*iso*-Pr (Val)	*tert*-Bu	2.5:1.0	85
9	**4**	CF_2CH_3	L-**8a**	**9i**	Me (Ala)	*tert*-Bu	2.3:1.0	80
10	**4**	CF_2CH_3	L-**8b**	**9j**	*sec*-Bu (Ile)	Me	3.3:1.0	82
11	**4**	CF_2CH_3	L-**8c**	**9k**	Bn (Phe)	*tert*-Bu	2.5:1.0	63
12	**4**	CF_2CH_3	L-**8d**	**9l**	*iso*-Pr (Val)	*tert*-Bu	4.2:1.0	74
13	**5**	CF_2Cl	L-**8a**	**9m**	Me (Ala)	*tert*-Bu	4.0:1.0	74
14	**5**	CF_2Cl	L-**8b**	**9n**	*sec*-Bu (Ile)	Me	8.8:1.0	69
15	**5**	CF_2Cl	L-**8c**	**9o**	Bn (Phe)	*tert*-Bu	4.8:1.0	75
16	**5**	CF_2Cl	L-**8d**	**9p**	*iso*-Pr (Val)	*tert*-Bu	10.0:1.0	76
17	**6**	CF_2Br	L-**8a**	**9q**	Me (Ala)	*tert*-Bu	4.2:1.0	77
18	**6**	CF_2Br	L-**8b**	**9r**	*sec*-Bu (Ile)	Me	8.1:1.0	65
19	**6**	CF_2Br	L-**8c**	**9s**	Bn (Phe)	*tert*-Bu	6.5:1.0	70
20	**6**	CF_2Br	L-**8d**	**9t**	*iso*-Pr (Val)	*tert*-Bu	10.3:1.0	93
21	**7**	CF_2CF_3	L-**8a**	**9u**	Me (Ala)	*tert*-Bu	3.5:1.0	70
22	**7**	CF_2CF_3	L-**8b**	**9v**	*sec*-Bu (Ile)	Me	8.1:1.0	66
23	**7**	CF_2CF_3	L-**8c**	**9w**	Bn (Phe)	*tert*-Bu	5.9:1.0	74
24	**7**	CF_2CF_3	L-**8d**	**9y**	*iso*-Pr (Val)	*tert*-Bu	10.2:1.0	90
25	**2**	CF_3	L-**8e**	**9z**	*iso*-Pr (Val)	Bn	11.2:1.0	79

[a] See Ref. [7].
[b] Determined by ^1H and ^{19}F NMR.
[c] Overall isolated yields.
[d] Stereochemistry not assigned.
[e] Inseparable mixture.

It clearly appears that very subtle differences such as the presence of F instead of H, Cl or Br in the R_F group of the nitroalkene acceptor bring about a striking effect in terms of stereocontrol of the process. Insufficient data exist at present to allow a detailed mechanistic discussion on the stereolectronic effect of the R_F group. However, based on the current experimental data, we can reliably assume that (1) the reaction is under kinetic control, (2) the aminoester nucleophile reacts with a rigid conformation due to the presence of an intramolecular N–H···O═C hydrogen bond, (3) the fluorinated residue greatly stabilizes the LUMO of the nitroalkenes, making these Michael acceptors more electrophilic than the parent unfluorinated compounds (4) the reaction involves a tight, polar transition state, which is destabilized and disrupted in polar solvents, decreasing the stereocontrol, (5) the base DIPEA appears to play a fundamental catalytic role, presumably by promoting the formation of a ternary transition state involving nucleophile, Michael acceptor and amine base, in analogy with related processes we have studied in the recent past [15]. Clearly, these results demonstrate that electronic factors can overcome steric factors in the control of the diastereoselectivity of aza-Michael reactions. A possible transition state leading to the major diastereomers **9** is portrayed in Fig. 3. According to this hypothesis the nitroalkenes react in the dominant (*E*)-geometry from the *Re* diastereoface and one amine proton of the nucleophile is hydrogen bonded both with the C═O and with a NO_2 oxygen, whereas the H-transfer from the NH_2 group to the α-nitro position is assisted by Hunig's base catalyst.

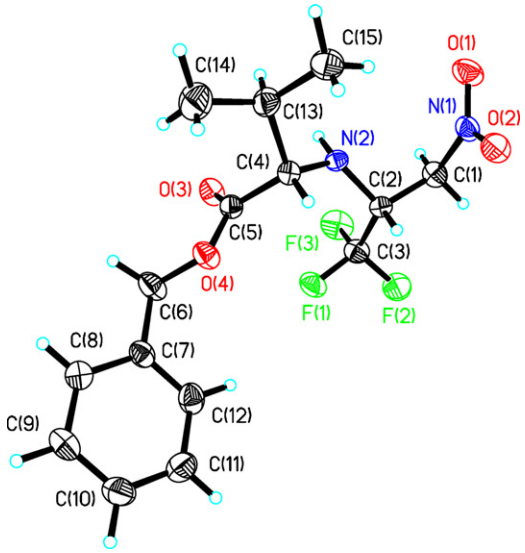


Fig. 2. ORTEP view of **10z**.

Elaboration of the major adducts **9** into the target Ψ[CH(R_F)NH]Gly-peptides **11** (Scheme 2) was addressed next. Reduction of the nitro group of **9** was accomplished by using Perlman's catalyst in the presence of aqueous 1N HCl to trap the free amino function as hydrochloride salt. Coupling with Boc(Cbz)-L-Phe-OH using HOBt/EDC afforded Boc(Cbz)-L-Phe-Ψ[CH(R_F)NH]Gly-L-Val-O*t*Bu **11**, in very good yields.

In summary, we have reported on the synthesis of a new class of peptidomimetics having diverse [CH(R_F)NH] functions as surro-

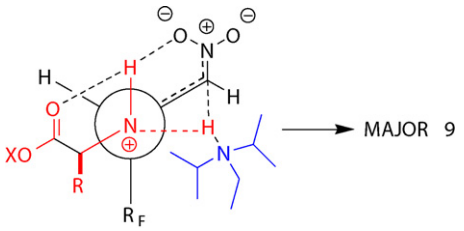


Fig. 3. Possible transition state leading to the major diastereomers **9**.

gates of the scissile peptide bond, namely Ψ[CH(R_F)NH]Gly-peptides. The aza-Michael addition of α-aminoacid esters **8** to fluoroalkyl nitroethenes **2–7** represents the key synthetic step. The diastereoselectivity of this reaction, which was already known to be dependent on the base and its stoichiometry, solvent, temperature and R side chain of **8** [7], proved to be strongly influenced also by the electronegativity, rather than the steric bulk, of the fluorinated R_F group in the β-position to the nitroethene acceptors.

1. Experimental

1.1. General details

Commercially available reagent-grade solvents were employed without purification. Melting points (m.p.) are uncorrected and were obtained on a capillary apparatus. TLC were run on silica gel 60 F_{254} Merck. Flash chromatographies (FC) were performed with silica gel 60 (60–200 m, Merck). ^{1}H, ^{13}C, and ^{19}F NMR spectra were run at 250, 400 or 500 MHz. Chemical shifts are expressed in ppm (δ), using tetramethylsilane (TMS) as internal standard for ^{1}H and ^{13}C nuclei (δ_H and $\delta_C = 0.00$), while C_6F_6 was used as external standard (δ_F −162.90) for ^{19}F. ^{1}H, ^{19}F and ^{13}C NMR spectral data of nitroalkenes **2**, **3**, **5** and **7** were in agreement with those previously reported [12].

1.2. Preparation of β-fluoroalkyl-α-nitroethenes 2–7: typical procedure (see also Ref. [12])

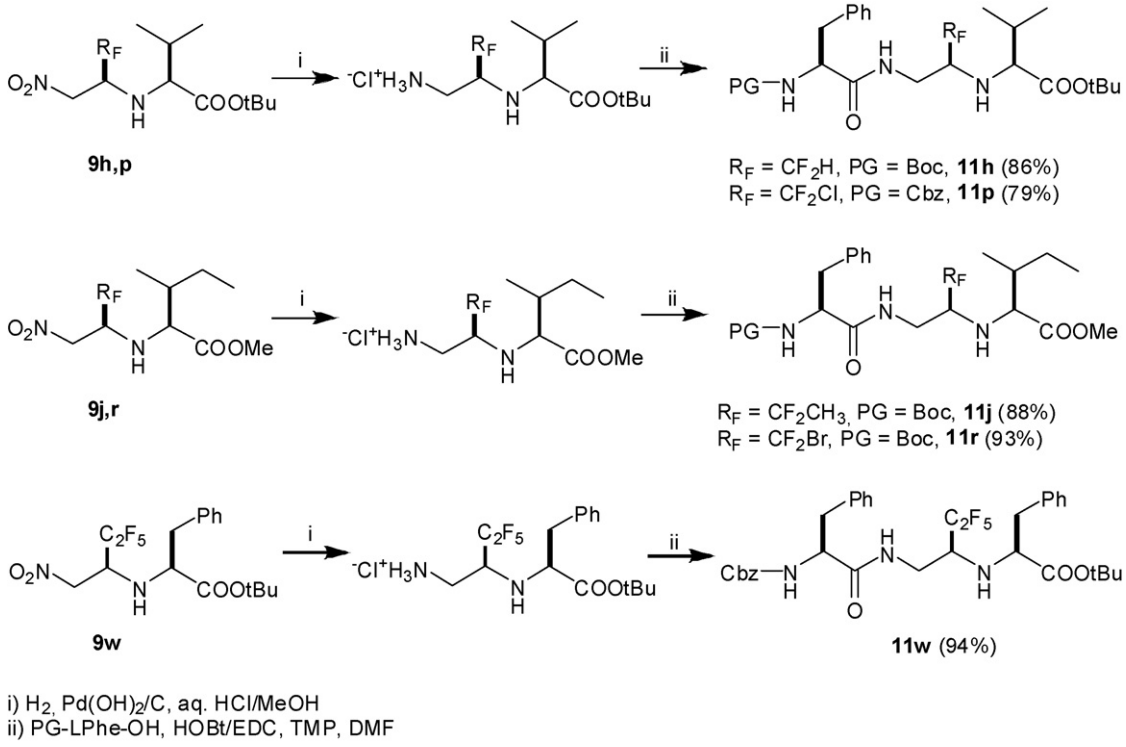
Fluoral hydrate (aq. solution 75%, 6.65 g, 43 mmol), nitromethane (7.87 g, 129 mmol) and sodium carbonate (280 mg, 2.64 mmol) were mixed at rt under vigorous stirring. The mixture was heated at 60 °C (in a few minutes a red-orange coloration appeared) for 3 h and then stirred at rt overnight. The mixture was extracted in diethyl ether, the organic layer was dried with anhydrous Na_2SO_4 and then filtered. The organic solvent was carefully removed *in vacuo* at low temperature. The resulting light orange oil was treated with P_2O_5 (6.5 g, 46 mmol) added in one portion and the mixture submitted to fractional distillation at atmospheric pressure. Nitroalkene **2** was obtained as a green-yellow liquid distilled at 83–85 °C (3.75 g, 70%). Spectroscopic data matched those reported in the literature.

1.3. Michael addition: typical procedure

To a stirred solution of **2** (0.76 mmol, 107 mg) and **8** (0.51 mmol, 92 mg) in toluene (7 ml) at rt, DIPEA was added (0.56 mmol, 73 μl). After half an hour at rt, the solvent was removed in vacuo, the crude product was dissolved in EtOAc and washed once with 1N HCl. The organic layer was dried over anhydrous Na_2SO_4. The solvent was removed in vacuo, and the crude product was purified by FC (hexane/diisopropyl ether 9:1) affording 110 mg (75%) of the two pure diastereoisomers **9b** (R_f = 0.31, *n*-Hex/*i*Pr_2O 7:3) and **10b** (R_f = 0.41, *n*-Hex/*i*Pr_2O 7:3), in 6.0:1.0 ratio.

1.4. Synthesis of the fluorinated tripeptide mimics 11: typical procedure

A solution of **9m** (0.11 mmol, 33 mg) and 1N HCl (0.11 mmol, 110 μl), in MeOH (2 ml), in the presence of a catalytic amount of



Scheme 2. Elaboration of the major aza-Michael adducts **9** into the target peptidomimetics **11**.

palladium hydroxide on carbon, was stirred at rt for 5 h, under hydrogen atmosphere. Then, the mixture was filtered on a Celite pad and the solvent was removed in vacuo. The crude product was dissolved in 1 ml of dry DMF and Cbz-L-Phe-OH, (0.11 mmol, 32.9 mg) followed by *sym* collidine (0.22 mmol, 30 μl), HOAt (0.11 mmol, 14.9 mg), HATU (0.11 mmol, 41.8 mg) were added at rt. The mixture was stirred overnight, quenched with 1N HCl, and extracted with Et_2O. The organic layer was washed once with water and then dried on Na_2SO_4. The solvent was removed in vacuo, and the crude product purified by FC (hexane/AcOEt 70:30) affording 50.6 mg of **11m** (79%).

4: ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.29 (dt, J = 13.7, 1.9 Hz, 1H), 7.10 (dt, J = 13.2, 10.9 Hz, 1H), 1.85 (t, J = 18.4 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −92.27 (ddq, J = 252.8, 19.3, 9.2 Hz, 1F), −92.36 (ddq, J = 252.8, 19.3, 12.3 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 142.66, 134.13 (t, J = 28.8 Hz), 118.72 (t, J = 239.1 Hz), 24.24 (t, J = 27.9 Hz); ESI (m/z) 283.0 [M$^+$+H, (100)], 305.0 [M$^+$+Na, (11)].

6: ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.31 (m, 2H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −51.41 (d, J = 2.3 Hz, 1F), −51.44 (d, J = 1.8 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 141.85, 133.07 (t, J = 27.1 Hz), 113.10 (t, J = 300.9 Hz).

9b: R_f = 0.34 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = -25.4^\circ$ (c = 0.56, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.66 (dd, J = 13.7, 4.6 Hz, 1H), 4.56 (dd, J = 13.3, 7.1 Hz, 1H), 3.90 (m, 1H), 3.37 (dd, J = 8.8, 5.6 Hz, 1H), 1.80 (m, 2H), 1.48 (m, 2H), 1.47 (s, 9H), 1.40 (m, 1H), 0.92 (d, J = 5.6 Hz, 3H), 0.90 (d, J = 5.6, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −76.45 (d, J = 7.01 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.26, 126.15 (q, J = 282.2 Hz), 81.99, 74.49, 60.04, 57.92, (q, J = 29.7), 43.21, 27.91, 24.64, 24.35, 21.81; ESI (m/z) 353.1 [M$^+$+Na, (100)], 369.1 [M$^+$+K, (19)].

10b: R_f = 0.35 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{23} = +6.5^\circ$ (c = 0.25, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.60 (dd, J = 20.9, 6.0 Hz, 1H), 4.38 (dd, J = 20.9, 16.1 Hz, 1H), 3.96 (m, 1H), 3.23 (dd, J = 25.8, 11.2 Hz, 1H), 2.11 (m, 1H), 1.67 (m, 2H), 1.55 (br s, 1H), 1.48 (s, 9H), 0.88 (d, J = 8.64 Hz, 3H), 0.86 (d, J = 8.6, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −74.92 (d, J = 7.01 Hz, 3F); ESI (m/z) 351.2 [M$^+$+Na, (100)], 367.1 [M$^+$+K, (35)].

9e (stereochemistry not assigned): R_f = 0.34 (hexane:diisopropyl ether 7:3); $[\alpha]_D^{20} = +3^\circ$ (c = 0.25, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.06 (dt, J = 55.4, 3.1 Hz, 1H), 4.60 (dd, J = 13.1, 4.0 Hz, 1H), 4.45 (dd, J = 13.1, 8.3 Hz, 1H), 3.65 (m, 1H), 3.35 (q, J = 7.4 Hz, 1H), 1.95 (br s, 1H), 1.46 (s, 9H), 1.25 (d, J = 7.1 Hz, 1H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −124.0 (ddd, J = 290.5, 55.4, 7.4 Hz, 1F), −131.1 (ddd, J = 290.5, 55.4, 20.0 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.95, 115.35 (t, J = 245.8 Hz), 82.14, 74.81, 57.91 (t, J = 21.2), 56.85, 28.34, 20.07; ESI (m/z) 291.1 [M$^+$+Na, (100)].

10e (stereochemistry not assigned): R_f = 0.33 (hexane:diisopropyl ether 7:3); $[\alpha]_D^{20} = -12.0^\circ$ (c = 0.58, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.90 (dt, J = 55.6, 3.4 Hz, 1H), 4.66 (dd, J = 13.4, 4.6 Hz, 1H), 4.55 (dd, J = 13.4, 6.8 Hz, 1H), 3.63 (m, 1H), 3.43 (q, J = 6.8 Hz, 1H), 1.98 (br s, 1H), 1.47 (s, 9H), 1.28 (d, J = 7.1 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −124.5 (ddd, J = 288.3, 55.6, 19 Hz, 1F), −129.6 (ddd, J = 288.0, 56.7, 19 Hz, 1F); ESI (m/z) 291.1 [M$^+$+Na, (100)].

9f (stereochemistry not assigned, obtained in mixture with **10f**): R_f = 0.34 (hexane:AcOEt 9:1); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.84 (dt, J = 55.6, 3.4 Hz, 1H), 4.60 (dd, J = 13.7, 4.3 Hz, 1H), 4.52 (dd, J = 13.7, 6.8 Hz, 1H), 3.71 (s, 3H), 3.55 (m, 2H), 3.28 (d, J = 5.1 Hz, 1H), 1.72 (m, 1H), 1.45 (m, 1H), 1.1 (m, 1H), 0.92 (d, J = 6.8 Hz, 3H), 0.86 (d, J = 9.7 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −124.4 (dd, J = 287.2, 55.6 Hz, 1F), −130.0 (ddd, J = 287.2, 55.6, 16.7 Hz, 1H); ESI (m/z) 291.1 [M$^+$+Na, (100)].

10f (stereochemistry not assigned, obtained in mixture with **9f**): R_f = 0.34 (hexane:AcOEt 9:1); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.99 (dt, J = 55.6, 3.4 Hz, 1H), 4.58 (dd, J = 13.1, 4.0 Hz, 1H), 4.44 (dd, J = 13.1, 8.6 Hz, 1H), 3.73 (s, 3H), 3.6 (m, 2H), 3.21 (d, J = 5.4 Hz, 1H), 1.7 (m, 1H), 1.4 (m, 1H), 1.11 (m, 1H), 0.87 (t, J = 7.7 Hz, 6H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −124.3 (dd, J = 286.1, 55.6 Hz, 1F), −139.8 (ddd, J = 286.1, 55.6, 15.6 Hz, 1H); ESI (m/z) 291.1 [M$^+$+Na, (100)].

9g (stereochemistry not assigned, obtained in mixture with **10g**): R_f = 0.34 (hexane:diisopropyl ether 8:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.6–7.1 (m, 5H), 5.63 (td, J = 55.6, 3.21 Hz, 1H), 4.48 (dd, J = 13.5, 4.5 Hz, 1H), 4.46 (dd, 13.5, 7.38 Hz, 1H), 3.57 (m, 1H), 2.68 (dd, J = 13.5, 5.46 Hz, 1H), 2.81 (dd, J = 13.5, 7.7 Hz, 1H), 1.42 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −124.0 (ddd, J = 285.9, 55.1, 7.7 Hz, 1F), −129.6 (ddd, J = 285.9, 55.1, 17.9 Hz, 1H); ESI (m/z) 345.1 [M$^+$+H, (13)], 367.0 [M$^+$+Na, (100)], 383.0 [M$^+$+K, (20)].

10g (stereochemistry not assigned, obtained in mixture with **9g**): R_f = 0.34 (hexane:diisopropyl ether 8:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.6–7.1 (m, 5H), 5.96 (td, J = 55.6, 3.21 Hz, 1H), 4.48 (dd, J = 13.5, 5.1 Hz, 1H), 4.32 (dd, 13.5, 8.0 Hz, 1H), 3.51 (m, 1H), 2.92 (dd, J = 13.8, 6.1 Hz, 1H), 2.82 (dd, J = 13.5, 7.4 Hz, 1H), 1.44 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −123.9 (ddd, J = 288.5, 55.1, 7.7 Hz, 1F), −129.7 (ddd, J = 288.5, 55.1, 16.7 Hz, 1H); ESI (m/z) 345. [M$^+$+H, (5)], 367.0 [M$^+$+Na, (100)], 383.0 [M$^+$+K, (25)].

9h: R_f = 0.34 (hexane: AcOEt 92:8); $[\alpha]_D^{20} = -14^\circ$ (c = 0.36, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.87 (dt, J = 55.6, 3.4 Hz, 1H), 4.66 (dd, J = 13.7, 4.3 Hz, 1H), 4.55 (dd, J = 13.7, 6.8 Hz, 1H), 3.57 (m, 1H), 3.11 (d, J = 4.8 Hz, 1H), 2.03 (s, 1H), 1.99 (m, 1H), 1.47 (s, 9H), 0.97 (d, J = 6.8 Hz, 3H), 0.86 (d, J = 6.8 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −123.8 (ddd, J = 285.4, 55.6, 7.8 Hz, 1F), −130.0 (ddd, J = 285.4, 55.6, 18.0 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.17, 115.81 (t, J = 247.2 Hz), 82.26, 74.40, 58.52 (t, J = 22.04 Hz), 32.31, 18.37, 19.67, 17.62; ESI (m/z) 319.1 [M$^+$+Na, (100)], 335.1 [M$^+$+K, (35)].

10h: R_f = 0.33 (hexane:AcOEt 92:8); $[\alpha]_D^{20} = +9^\circ$ (c = 0.2, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.00 (dt, J = 55.6, 3.4 Hz, 1H), 4.58 (dd, J = 13.1, 4.3 Hz, 1H), 4.44 (dd, J = 13.1, 8.6, 1H), 3.56 (m, 1H), 2.99 (d, J = 5.1 Hz, 1H), 1.91 (m, 2H), 1.48 (s, 9H), 0.91 (d, J = 6.8 Hz, 3H), 0.83 (d, J = 0.83 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −124.2 (ddd, J = 288.9, 55.5, 8.2 Hz, 1F), −130.2 (ddd, J = 288.9, 55.6, 17.9 Hz, 1F); ESI (m/z) 319.1 [M$^+$+Na, (100)], 335.1 [M$^+$+K, (15)].

9i: R_f = 0.33 (hexane:diisopropyl ether 85:15); $[\alpha]_D^{20} = -32.3^\circ$ (c = 2.8, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.69 (dd, J = 13.7, 4.8 Hz, 1H), 4.48 (dd, J = 13.7, 7.3 Hz, 1H), 3.63 (m, 1H), 3.38 (q, J = 7.0 Hz, 1H), 1.92 (br s, 1H), 1.69 (t, J = 19.1 Hz, 3H), 1.44 (s, 9H), 1.26 (d, J = 7.0 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −96.2 (ddq, J = 249.7, 19.4, 5.0 Hz, 1F), −104.2 (dquint, J = 249.7, 18.8 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.74, 124.13 (t, J = 243.3 Hz), 82.09, 75.32, 60.61 (t, J = 25.4 Hz), 56.83, 28.27, 20.91 (t, J = 26.3 Hz) 20.41 1; ESI (m/z) 305.2 [M$^+$+Na, (100)], 321.0 [M$^+$+K, (23)].

10i: R_f = 0.32 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = -3.7^\circ$ (c = 0.55, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.62 (dd, J = 13.0, 4.1 Hz, 1H), 4.36 (dd, J = 13.0, 8.6 Hz, 1H), 3.74 (m, 1H), 3.35 (q, J = 7.0 Hz, 1H), 1.98 (br, 1H), 1.70 (t, J = 19.1 Hz, 3H), 1.47 (s, 9H), 1.23 (d, J = 6.7 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −95.2 (ddq, J = 251.2, 26.1, 7.0 Hz, 1F), −101.3 (dquint, J = 251.2, 15.3 Hz, 1F); ESI (m/z) 305.2 [M$^+$+Na, (100)], 321.0 [M$^+$+K, (4)].

9j: R_f = 0.34 (hexane:AcOEt 9:1); $[\alpha]_D^{20} = -26.0^\circ$ (c = 2.8, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.68 (dd, J = 13.4, 4.4 Hz, 1H), 4.42 (dd, J = 13.4, 7.3 Hz, 1H), 3.69 (s, 3H), 3.57 (m, 1H), 3.29 (br s, 1H), 1.85 (br s, 1H), 1.70 (m, 1H), 1.99 (t, J = 19.1 Hz, 3H), 1.45 (m, 1H), 1.17 (m, 1H), 0.92 (d, J = 7.0 Hz, 3H), 0.88 (t, J = 7.6 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −95.3 (ddq, J = 250.2, 19.3, 4.9 Hz, 1F), −103.8 (dquint, J = 250.2, 19.2 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 175.24, 124.07 (t, J = 243.3 Hz), 75.44, 66.03, 61.60 (t,

J = 26.3 Hz), 52.13, 39.43, 25.23, 20.89 (t, J = 26.3 Hz), 16.13, 11.73; ESI (m/z) 283.0 [M$^+$+Na, (100)], 305.0 [M$^+$+K, (14)].

10j: R_f = 0.33 (hexane:AcOEt 9:1); $[\alpha]_D^{20} = +20.0^\circ$ (c = 0.2, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.59 (dd, J = 12.7, 4.2 Hz, 1H), 4.35 (dd, J = 12.7, 8.9 Hz, 1H), 3.73 (s, 3H), 3.71 (s br, 1H), 3.24 (s br, 1H), 1.97 (s br, 1H), 1.67 (t, J = 19.3 Hz, 3H), 1.70 (m, 1H) 1.65 (m, 1H), 1.43 (m, 1H), 1.14 (m, 1H), 0.87 (t, J = 7.5 Hz, 3H), 0.85 (d, J = 6.7 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −96.0 (ddq, J = 252.8, 19.3, 9.2 Hz, 1F), −98.8 (ddq, J = 252.8, 19.3, 12.3 Hz, 1F); ESI (m/z) 283.0 [M$^+$+Na, (100)], 305.0 [M$^+$+K, (11)].

9k: R_f = 0.36 (hexane:AcOEt 9:1); $[\alpha]_D^{20} = -22.4^\circ$ (c = 0.9, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.3–7.1 (m, 5H), 4.66 (dd, J = 13.7, 4.8 Hz, 1H), 4.44 (dd, J = 13.7, 7.0 Hz, 1H), 3.67 (m, 2H), 3.00 (dd, J = 13.7, 5.4 Hz, 1H), 2.75 (dd, J = 13.7, 8.3 Hz, 1H), 1.84 (br s, 1H), 1.42 (s, 9H), 1.39 (t, J = 19.1 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −95.3 (ddq, J = 250.0, 19.1, 4.1 Hz, 1F), −104.5 (dquint, J = 250.0, 19.1 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 173.92, 137.79, 129.82, 128.70, 127.10, 124.12 (t, J = 243.3 Hz), 82.54, 75.38, 63.23, 61.25 (t, J = 25.4 Hz), 41.11, 28.28, 20.64 (t, J = 26.3 Hz); ESI (m/z) 381.0 [M$^+$+Na, (100)], 397.0 [M$^+$+K, (31)].

10k: R_f = 0.35 (hexane:AcOEt 9:1); $[\alpha]_D^{20} = +32.3^\circ$ (c = 0.6, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.4–7.1 (m, 5H), 4.51 (dd, J = 13.2, 4.7 Hz, 1H), 4.20 (dd, J = 13.2, 8.0 Hz, 1H), 3.71 (m, 1H), 3.52 (t, J = 6.6 Hz, 1H), 2.92 (dd, J = 13.6, 6.1 Hz, 1H), 2.79 (dd, J = 13.6, 7.1 Hz, 1H), 1.94 (br s, 1H), 1.64 (t, J = 19.3 Hz, 3H), 1.40 (s, 9H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −95.7 (ddq, J = 252.2, 19.3, 7.7 Hz, 1F), −100.7 (ddq, J = 252.2, 19.3, 15.5 Hz, 1F); ESI (m/z) 381.0 [M$^+$+Na, (100)], 397.0 [M$^+$+K, (6)].

9l: R_f = 0.35 (hexane:AcOEt 97:3); $[\alpha]_D^{20} = -27.3^\circ$ (c = 4.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.69 (dd, J = 13.7, 4.8 Hz, 1H), 4.45 (dd, J = 13.7, 6.7 Hz, 1H), 3.55 (d, 1H), 3.09 (br s, 1H), 1.96 (m, 1H), 1.83 (br s, 1H), 1.72 (t, J = 19.2 Hz, 3H), 1.44 (s, 9H), 0.96 (d, J = 7.0 Hz, 3H), 0.85 (d, J = 7.0 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −95.1 (ddq, J = 251.5, 19.0, 3.7 Hz, 1F), −104.7 (dquint, J = 251.5, 20.3 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.39, 124.26 (t, J = 243.3 Hz), 82.20, 75.35, 67.09, 61.85 (t, J = 25.4 Hz), 32.66, 28.32, 21.15 (t, J = 26.3 Hz) 19.81, 17.62 1; ESI (m/z) 333.0 [M$^+$+Na, (100)], 349.0 [M$^+$+K, (21)].

10l: R_f = 0.34 (hexane:AcOEt 97:3); $[\alpha]_D^{20} = +21.1^\circ$ (c = 0.6, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.57 (dd, J = 12.7, 4.1 Hz, 1H), 4.32 (dd, J = 12.7, 8.9 Hz, 1H), 3.69 (m, 1H), 3.03 (d, J = 5.1 Hz, 1H), 1.85 (m, 1H), 1.66 (t, J = 19.1 Hz, 3H), 1.61 (s, 9H), 0.89 (d, J = 6.7 Hz, 3H), 0.84 (d, J = 6.7 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −95.6 (ddq, J = 252.6, 19.1, 9.2 Hz, 1F), −95.7 (ddq, J = 252.6, 19.1, 10.8 Hz, 1F); ESI (m/z) 333.0 [M$^+$+Na, (100)], 349.0 [M$^+$+K, (11)].

9m: R_f = 0.35 (hexane:AcOEt 95:5); $[\alpha]_D^{20} = -25.4^\circ$ (c = 0.56, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.71 (dd, J = 13.4, 4.3 Hz, 1H), 4.54 (dd, J = 13.4, 7.7 Hz, 1H), 4.06 (m, 1H), 3.49 (m, 1H), 1.98 (br, 1H), 1.4 (s, 9H), 1.29 (d, J = 6.8, 2H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −61.0 (dd, J = 166.7, 7.6 Hz, 1F), −61.5 (dd, J = 166.7, 6.7 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.14, 129.12 (t, J = 297.5 Hz), 75.46, 62.74 (t, J = 26.3 Hz), 56.74, 30.80, 29.67, 19.92; ESI (m/z) 325.1 [M$^+$+Na, (100)], 341.0 [M$^+$+K, (8)].

10m: R_f = 0.36 (hexane:AcOEt 95:5); $[\alpha]_D^{20} = +25.4^\circ$ (c = 0.26, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.70 (dd, J = 12.6, 3.2 Hz, 1H), 4.42 (dd, J = 12.6, 9.7 Hz, 1H), 4.11 (m, 1H), 3.44 (m, 1H), 1.46 (s, 9H), 2.45 (br s, 1H), 1.24 (d, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −58.7 (dd, J = 168.8, 4.3Hz, 1F), −60.4 (dd, J = 168.8, 8.8 Hz, 1F); ESI (m/z) 325.1 [M$^+$+Na, (100)], 341.0 [M$^+$+K, (17)].

9n: R_f = 0.33 (hexane:diisopropylether 85:15): $[\alpha]_D^{20} = -44.0^\circ$ (c = 2.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.3–7.15 (m, 5H), 4.65 (dd, J = 13.5, 4.5 Hz, 1H), 4.47 (dd, J = 13.5, 7.7 Hz, 1H), 4.05 (m, 1H), 3.69 (q, J = 6.7 Hz, 1H), 2.99 (dd, J = 13.5, 5.8 Hz, 1H), 2.88 (dd, J = 13.5, 7.4 Hz, 1H), 1.37 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −60.21 (dd, J = 166.8, 8.2 Hz, 1F), −61.04 (dd, J = 166.8, 6.8 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 172.93, 136.89, 129.90, 129.44 (t, J = 298.4 Hz), 128.76, 127.29, 82.65, 75.73, 63.25 (t, J = 25.43 Hz), 62.67, 40.52, 28.26; ESI (m/z) 401.0 [M$^+$+Na, (100)], 413.2 [M$^+$+K, (21)].

10n: R_f = 0.34 (hexane:diisopropylether 85:15): $[\alpha]_D^{20} = -26.7^\circ$ (c = 0.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.3–7.15 (m, 5H), 4.71 (dd, J = 13.2, 2.9 Hz, 1H), 4.29 (dd, J = 13.2, 9.3 Hz, 1H), 4.04 (m, 1H), 3.56 (7, J = 7.1 Hz, 1H), 2.99 (dd, J = 13.5, 6.1 Hz, 1H), 2.81 (dd, J = 13.5, 6.1 Hz, 1H), 1.39 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −58.811 (d, J = 169.3 Hz, 1F), −60.63 (dd, J = 169.3, 9.4 Hz, 1F); ESI (m/z) 401.0 [M$^+$+Na, (100)], 413.2 [M$^+$+K, (34)].

9o: R_f = 0.33 (hexane:diisopropylether 9:1): $[\alpha]_D^{20} = -11.9^\circ$ (c = 3.8, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.71 (dd, J = 13.2, 4.2 Hz, 1H), 4.52 (dd, J = 13.5, 7.7 Hz, 1H), 3.93 (m, 1H), 3.71 (s, 3H), 3.38 (d, J = 5.1 Hz, 1H), 2.34 (t, J = 9.9 Hz, 1H), 1.73 (m, 1H), 1.45 (m, 1H), 1.17 (m, 2H), 0.92 (d, J = 6.7 Hz, 3H), 0.88 (t, J = 7.4 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −60.22 (dd, J = 166.9, 7.7 Hz, 1F), −61.1 (dd, J = 166.9, 6.7 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.93, 129.40 (t, J = 296.7 Hz), 75.80, 66.27, 63.57 (t, J = 26.3 Hz), 52.29, 39.02, 25.12, 16.04, 11.73; ESI (m/z) 270.1 [M$^+$+Na, (100)].

10o: R_f = 0.35 (hexane:diisopropylether 9:1): $[\alpha]_D^{20} = +35.3^\circ$ (c = 0.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.69 (dd, J = 12.7, 3.3 Hz, 1H), 4.41 (dd, J = 12.7, 9.9 Hz, 1H), 4.06 (m, 1H), 3.74 (s, 3H), 3.27 (dd, J = 8.0, 5.2 Hz, 1H), 1.61 (m, 1H), 1.39 (m, 2H), 1.13 (m, 1H), 0.88 (t, J = 7.5 Hz, 3H), 0.84 (d, J = 7.1 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −58.45 (dd, J = 169.5, 3.9 Hz, 1F), −60.8 (dd, J = 169.5, 10.4 Hz, 1F); ESI (m/z) 270.1 [M$^+$+Na, (100)], 292.0 [M$^+$+K, (28)].

9p: R_f = 0.33 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{23} = -29.5^\circ$ (c = 1.8, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.72 (dd, J = 13.7, 4.2 Hz, 1H), 4.56 (dd, J = 13.7, 7.0 Hz, 1H), 3.95 (m, 1H), 3.18 (dd, J = 8.3, 4.5 Hz, 1H), 1.97 (m, 1H), 1.95 (s br, 1H), 1.47 (s, 9H), 0.98 (d, J = 6.8 Hz, 3H), 0.88 (d, J = 6.8, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −60.6 (dd, J = 166.2, 7.5 Hz, 1F), −61.5 (dd, J = 166.2, 6.7 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 173.52, 129.14 (t, J = 296.7 Hz), 82.04, 75.53, 67.13, 63.55 (t, J = 26.28 Hz) 33.00, 28.00, 19.26, 17.39; ESI (m/z) 353.1 [M$^+$+Na, (100)], 369.1 [M$^+$+K, (9)].

10p: R_f = 0.34 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{23} = +16.0^\circ$ (c = 0.25, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.61 (dd, J = 12.8, 3.4 Hz, 1H), 4.32 (dd, J = 12.8, 10 Hz, 1H), 3.95 (m, 1H), 3.00 (d, J = 4.5 Hz, 1H), 2.24 (s br, 1H), 1.81 (m, 1H), 1.32 (s, 9H), 0.80 (d, J = 6.8 Hz, 3H), 0.74 (d, J = 7.4, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −58.2 (dd, J = 168.4, 4.3 Hz, 1F), −60.8 (dd, J = 168.4, 8.5 Hz, 1F); ESI (m/z) 353.1 [M$^+$+Na, (100)], 369.1 [M$^+$+K, (20)].

9q: R_f = 0.35 (hexane:AcOEt 7:3): $[\alpha]_D^{20} = -40.1^\circ$ (c = 0.91, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.72 (dd, J = 13.4, 4.3 Hz, 1H), 4.54 (dd, J = 13.4, 7.7 Hz, 1H), 3.98 (m, 1H), 3.50 (q, J = 7.1 Hz, 1H), 1.97 (br s, 1H), 1.44 (s, 9H), 1.31 (d, J = 6.8 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −54.3 (dd, J = 163.8, 8.2 Hz, 1F), −55.4 (dd, J = 163.8, 7.8 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.17, 124.18 (t, J = 311.1 Hz), 82.31, 76.26, 64.35 (t, J = 23.7 Hz), 57.06, 28.29, 20.09; ESI (m/z) 369.1 [M$^+$+Na, (100)], 387.0 [M$^+$+K, (21)].

10q: R_f = 0.33 (hexane:AcOEt 7:3): $[\alpha]_D^{20} = +20^\circ$ (c = 0.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.70 (dd, J = 13.1, 3.4 Hz, 1H), 4.38 (dd, J = 13.1, 9.4 Hz, 1H), 4.44 (m, 1H), 3.45 (m, 1H), 2.47, (br s, 1H), 1.47 (s, 9H), 1.24 (d, J = 7.1 Hz, 2H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −52.0 (dd, J = 166.5, 4.4 Hz, 1F), −54.4 (dd, J = 166.5, 10.2 Hz, 1F); ESI (m/z) 369.1 [M$^+$+Na, (100)].

9r: R_f = 0.33 (hexane:diisopropyl ether 75:25): $[\alpha]_D^{20} = -31.5^\circ$ (c = 3.8, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.73 (dd, J = 13.7, 3.8 Hz, 1H), 4.53 (dd, J = 13.7, 8.0 Hz, 1H), 3.39 (m, 1H), 3.75 (s, 3H), 3.39 (dd, J = 9.4, 5.6 Hz, 1H), 1.94 (t, J = 8 Hz, 1H), 1.75 (m, 1H), 1.46

(m, 1H), 1.92 (m, 1H), 0.94 (d, J = 7.1 Hz, 3H), 0.89 (t. J = 7.5 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.78, 124.09 (t, J = 311.10 Hz), 76.31, 66.17, 64.71 (t, J = 23.74 Hz), 52.29, 39.03, 30.03, 25.16, 16.12, 11.75; δ = −51.7 (dd, J = 167.9, 3.8 Hz, 1F), −54.9 (dd, J = 167.9, 11.1Hz, 1H); ESI (m/z) 370.9 [M$^+$+Na, (100)], 386.8 [M$^+$+K, (32)].

10r: R_f = 0.36 (hexane:diisopropyl ether 75:25): $[\alpha]_D^{20} = +13.4°$ (c = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.72 (dd, J = 12.7, 3.3 Hz, 1H), 4.40 (dd, J = 12.7, 9.9 Hz, 1H), 3.98 (m, 1H), 3.74 (s, 3H), 3.27 (dd, J = 8.5, 5.6 Hz, 1H), 2.35 (t, J = 9.4 Hz, 1H), 1.61 (m, 1H), 1.40 (m, 1H), 1.14 (m, 1H), 0.86 (t, J = 7.5 Hz, 3H), 0.84 (d, J = 7.1 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −51.7 (dd, J = 167.9, 3.8 Hz, 1F), −54.9 (dd, J = 167.9, 11.1Hz, 1H); ESI (m/z) 370.9 [M$^+$+Na, (100)], 386.8 [M$^+$+K, (16)].

9s: R_f = 0.36 (hexane:diisopropyl ether 75:25); $[\alpha]_D^{20} = -23.1°$ (c = 2.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.3–7.2 (m, 5H), 4.66 (dd, J = 13.7, 4.3 Hz, 1H), 4.47 (dd, J = 13.7, 7.7 Hz, 1H), 3.91 (m, 1H), 3.70 (q, J = 6.8 Hz, 1H), 2.00 (dd, J = 13.7, 6.0 Hz, 1H), 2.88 (dd, J = 13.7, 7.1 Hz, 1H), 1.99 (br s, 1H), 1.41 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −53.7 (dd, J = 164.7, 8.5 Hz, 1F), −54.7 (dd, J = 164.7, 6.5 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 172.9, 136.78, 129.87, 128.75, 127.08, 124.13 (t, J = 370.5 Hz), 82.63, 76.15, 64.27 (t, J = 24.05 Hz), 62.51, 40.39, 28.19; ESI (m/z) 445.0 [M$^+$+Na, (100)].

10s: R_f = 0.38 (hexane:diisopropyl ether 75:25); $[\alpha]_D^{20} = +21.3°$ (c = 0.20, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.4–7.2 (m, 5H), 4.61 (dd, J = 13.1, 3.7 Hz, 1H), 4.28 (dd, J = 13.1, 9.4 Hz, 1H), 3.92 (m, 1H), 3.55 (m, 1H), 2.88 (dd, J = 13.7, 5.7 Hz, 1H), 2.80 (dd, J = 13.7, 7.1 Hz, 1H), 2.39 (br s, 1H), 1.38 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −52.9 (dd, J = 167.3, 3.9 Hz, 1F), −54.5 (dd, J = 167.3, 10.2Hz, 1H); ESI (m/z) 445.0 [M$^+$+Na, (100)].

9t: R_f = 0.34 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = -30.6°$ (c = 4.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.72 (dd, J = 13.9, 4.3 Hz, 1H), 4.56 (dd, J = 13.9, 7.4 Hz, 1H), 3.86 (m, 1H), 3.19 (d, J = 5.1 Hz, 1H), 1.98 (m, 1H), 1.44 (s, 9H), 0.98 (d, J = 6.5 Hz, 3H), 0.89 (d, J = 6.5 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −53.9 (dd, J = 163.8, 8.3 Hz, 1F), −130.2 (dd, J = 163.8, 6.7 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 173.8, 124.18 (t, J = 311.9 Hz), 82.38, 76.34, 65.00 (t, J = 23.7 Hz), 32.48, 28.34, 19.66, 17.81; ESI (m/z) 397.0 [M$^+$+Na, (100)], 413.2 [M$^+$+K, (8)].

10t: R_f = 0.35 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = +33°$ (c = 0.20, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.69 (dd, J = 12.8, 3.4 Hz, 1H), 4.38 (dd, J = 12.8, 9.9 Hz, 1H), 3.93 (m, 1H), 3.06 (dd, J = 7.7, 4.6 Hz, 1H), 1.83 (m, 1H), 1.46 (s, 9H), 0.86 (d, J = 6.8 Hz, 3H), 0.80 (d, J = 6.8 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −51.4 (dd, J = 167.1 both Hz, 1F), −55.1 (dd, J = 167.1, 11.0 Hz, 1H); ESI (m/z) 376.3 [M$^+$+H, (23)], 397.0 [M$^+$+Na, (100)], 413.2 [M$^+$+K, (28)].

9u: R_f = 0.35 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = -12.8°$ (c = 0.25, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.74 (dd, J = 14.0, 4.6 Hz, 1H), 4.66 (dd, J = 14.0, 6.6 Hz, 1H), 4.09 (m, 1H), 3.39 (m, 1H), 1.98 (m, 1H), 1.45 (s, 9H), 1.27 (d, J = 7.1 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −81.7 (s, 3F), −117.9 (dd, J = 274.7, 5.5 Hz, 1F), −128.1 (dd, J = 274.7, 19.4 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.46, 118.73 (qt, J = 35.1, 286.68 Hz), 114.39 (tq, J = 35.1, 258.94 Hz), 82.06, 74.15, 57.21, 56.77 (t, J = 22.2 Hz), 27.83, 19.92; ESI (m/z) 360.3 [M$^+$+Na, (100)], 376.3 [M$^+$+K, (5)].

10u: R_f = 0.33 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = +24.0°$ (c = 0.63, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.65 (dd, J = 13.7, 7.4 Hz, 1H), 4.43 (dd, J = 13.7, 9.1 Hz, 1H), 4.18 (m, 1H), 3.39 (m, 1H), 1.64 (br s, 1H), 1.46 (s, 9H), 1.23 (d, J = 6.8 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −82.54 (s, 3F), −121.5 (dd, J = 277.6, 11.4 Hz, 1F), −123.3 (dd, J = 277.5, 12.4 Hz, 1F); ESI (m/z) 360.3 [M$^+$+Na, (100)], 376.3 [M$^+$+K, (23)].

9v: R_f = 0.35 (hexane:diisopropylether 9:1): $[\alpha]_D^{20} = -41.9°$ (c = 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.72 (dd, J = 14.1, 4.5 Hz, 1H), 4.61 (dd, J = 14.1, 6.7 Hz, 1H), 4.03 (m, 1H), 3.70 (s, 3H), 3.31 (q, J = 4.8 Hz, 1H), 1.86 (t, J = 9.6 Hz, 1H), 1.72 (m, 1H), 1.39 (m, 2H), 1.14 (m, 1H), 0.89 (d, J = 7.1 Hz, 3H), 0.86 (t, J = 7.4 Hz, 2H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −81.52 (s, 3F), −117.81 (dd, J = 276.8, 4.8 Hz, 1F), −127.06 (dd, J = 276.8, 18.9 Hz, 1F); ^{3}C NMR (100.6 MHz, $CDCl_3$): δ = 173.96, 119.00 (qt, J = 286.52, 39.7 Hz), 114.34 (tq, J = 261.24, 39.7 Hz), 74.91, 65.17, 58.01 (t, J = 22.89 Hz), 52.18, 39.88, 30.04, 25.60, 21.61; ESI (m/z) 337.0 (M+H($^+$, 359.0 [M$^+$+Na, (100)], 374.9 [M$^+$+K, (14)].

10v: R_f = 0.34 (hexane:diisopropylether 9:1): $[\alpha]_D^{20} = +4.7°$ (c = 4.2, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.62 (dd, J = 13.2, 3.3 Hz, 1H), 4.42 (dd, J = 13.2, 9.9 Hz, 1H), 4.11 (m, 1H), 3.43 (s, 3H), 3.28 (t, J = 7.1 Hz, 1H), 2.31 (t, J = 8.9 Hz, 1H), 1.71 (m, 1H), 1.41 (m, 2H), 1.14 (m, 1H), 0.92 (t, J = 7.5 Hz, 2H), 0.83 (t, J = 7.1 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −82.61 (s, 3F), −120.81 (dd, J = 278.8, 9.4 Hz, 1F), −123.57 (dd, J = 278.8, 15.1 Hz, 1F); ESI (m/z) 337.0 (M+H($^+$, 359.0 [M$^+$+Na, (100)], 374.9 [M$^+$+K, (9)].

9w: R_f = 0.35 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = -4.2°$ (c = 0.25, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.3–7.1 (m, 5H), 4.69 (dd, J = 14.6, 4.8 Hz, 1H), 4.61 (dd, J = 14.6, 6.6 Hz, 1H), 4.09 (m, 1H), 3.62 (dt, J = 9.1, 6.3 Hz, 1H), 2.93 (d, J = 6.3 Hz, 1H), 1.83 (br s, 1H), 1.39 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −81.6 (s, 3F), −117.6 (dd, J = 275.7, 5.9 Hz, 1F), −127.8 (dd, J = 275.7, 19.7 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 173.25, 136.46, 129.43, 128.28, 126.87, 125.43, 118.62 (qt, J = 34.8, 283.96 Hz), 113.96 (tq, J = 34.8, 236.4 Hz), 82.41, 74.12, 62.83, 57.21 (t, J = 20.4 Hz), 40.39, 27.80; ESI (m/z) 413.3 [M$^+$+H, (100)].

10w: R_f = 0.34 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = +16°$ (c = 0.20, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.3–7.1 (m, 5H), 4.59 (dd, J = 13.4, 4.6 Hz, 1H), 4.47 (dd, J = 13.7, 7.7 Hz, 1H), 3.95 (m, 1H), 3.65 (t, J = 6.6 Hz, 1H), 2.98 (dd, J = 13.7, 5.9 Hz, 1H), 2.88 (dd, J = 13.7, 7.1 Hz, 1H), 1.52 (br s, 1H), 1.37 (s, 9H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −82.7 (s, 3F), −122.8 (dd, J = 278.3, 6.3 Hz, 1F), −130.2 (dd, J = 278.3, 18.8 Hz, 1F); ESI (m/z) 413.3 [M$^+$+H, (100)].

9y: R_f = 0.34 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = -28.7°$ (c = 2.1, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.73 (dd, J = 14.5, 4.8 Hz, 1H), 4.65 (dd, J = 14.5, 5.7 Hz, 1H), 4.04 (m, 1H), 3.14 (dd, J = 9.9, 4.3 Hz, 1H), 2.05 (br s, 1H), 2.00 (m, 1H), 1.46 (s, 9H), 0.97 (d, J = 6.8 Hz, 3H), 0.84 (d, J = 6.8 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −81.2 (s, 3F), −117.1 (dd, J = 276.4, 5.1 Hz, 1F), −127.9 (dd, J = 276.4, 19.5 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 171.53, 122.81 (qt, J = 283.96, 34.81 Hz), 111.47 (tq, 256.48, 34.8 Hz), 79.55, 71.55, 64.49, 55.39 (t, J = 22.2 Hz), 29.50, 25.27, 16.56, 14.21; ESI (m/z) 364.3 [M$^+$+H, (100)], 386.2 [M$^+$+Na, (10)].

10y: R_f = 0.33 (hexane:diisopropyl ether 9:1); $[\alpha]_D^{20} = +10.0°$ (c = 0.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.60 (dd, J = 13.4, 3.7 Hz, 1H), 4.41 (dd, J = 13.4, 9.9 Hz, 1H), 4.02 (m, 1H), 3.06 (dd, J = 9.9, 4.6 Hz, 1H), 2.00 (m, 1H), 1.61 (br s, 1H), 1.47 (s, 9H), 0.97 (d, J = 7.1 Hz, 3H), 0.87 (d, J = 7.1 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −82.6 (s, 3F), −120.2 (dd, J = 276.6, 9.5 Hz, 1F), −124.2 (dd, J = 276.6, 15.3 Hz, 1F); ESI (m/z) 364.3 [M$^+$+H, (100)].

9z: $[\alpha]_D^{23} = -17.2°$ (c = 1.2, $CHCl_3$); FT IR (film): ν_{max} = 3363, 2966, 1732, 1566, 1382 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.41–7.33 (m, 5H), 5.18 (d, J = 12.2 Hz, 1H), 5.15 (d, J = 12.2 Hz, 1H), 4.64 (dd, J = 13.5, 4.3 Hz, 1H), 4.52 (dd, J = 13.5, 7.5 Hz, 1H), 3.91 (m, 1H), 3.32 (d, J = 5.3 Hz, 1H), 2.04 (m, 1H), 1.94 (br s, 1H), 0.97 (d, J = 6.5 Hz, 3H), 0.87 (d, J = 6.5 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −75.8 (d, J = 7.7 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$): δ = 174.1, 135.4, 128.62, 128.60, 128.5, 124.5 (q, J = 281.7 Hz), 74.3, 67.1, 66.6, 58.29 (q, J = 29.8 Hz), 31.9, 19.1, 17.3; MS (70 eV): e/z (%): 349 [M$^+$+1] (20), 213 (100), 91 (40).

10z: $[\alpha]_D^{23} = +22.9^\circ$ (c = 1.0, $CHCl_3$); FT IR (film): ν_{max} = 3345, 2967, 2919, 1733, 1567, 1382 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ = 7.41–7.31 (m, 5H), 5.15 (s, 2H), 4.59 (dd, J = 12.9, 3.6 Hz, 1H), 4.40 (dd, J = 12.9, 10.1 Hz, 1H), 3.94 (m, 1H), 3.20 (d, J = 4.6 Hz, 1H), 2.20 (br s, 1H), 1.90 (m, 1H), 0.86 (d, J = 6.5 Hz, 3H), 0.80 (d, J = 6.5 Hz, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −74.8 (d, J = 7.6 Hz); ^{13}C NMR (62.9 MHz, $CDCl_3$): δ = 173.5, 135.4, 128.6, 124.7 (q, J = 285.5 Hz), 74.7, 67.1, 66.3, 59.4 (q, J = 29.5 Hz), 32.7, 19.0, 17.2; MS (70 eV): e/z (%): 349 [M^++1] (20), 213 (100), 91 (40).

11h: R_f = 0.30 (hexane:AcOEt 8:2): $[\alpha]_D^{20} = +16.5^\circ$ (c = 2.1, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ = 7.35–7.15 (m, 5H), 5.51 (td, J = 56.1, 4.8 Hz, 1H), 5.22 (s br, 1H), 4.45 (s br, 1H), 3.43 (m, 1H), 3.27 (dt, J = 13.8, 3.9 Hz, 1H), 3.18 (dd, J = 13.8, 6.1 Hz, 1H), 3.00 (m, 1H), 2.65 (m, 1H), 1.96 (m, 1H), 1.61 (s br, 1H), 1.47 (s, 9H), 1.37 (s, 9H), 0.96 (d, 3H), 0.84 (d, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −53.3 (d, J = 163.4 Hz, 1F), −53.8 (d, J = 163.4 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 175.78, 172.47, 137.42, 129.77, 128.84, 127.10, 117.35 (t, J = 241.14 Hz), 82.21, 80.27, 66.39, 59.24 (t, J = 21.19 Hz), 39.24, 38.81, 31.94, 30.04, 28.63, 19.77, 17.83; ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −125.08 (ddd, J = 8.8, 56.1, 285.0 Hz, 1F), −126.46 (ddd, J = 11.4, 56.1, 285.0 Hz, 1F); ESI (m/z) 515.0 1 [M^++H, (100)], 537.1 [M^++Na, (41)].

11j: R_f = 0.34 (hexane:AcOEtr 7:3): $[\alpha]_D^{20} = +6.5^\circ$ (c = 2.5, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ = 7.3–7.15 (m, 5H), 6.87 (s, 1H), 5.22 (s br, 1H), 4.43 (s br, 1H), 3.71 (s, 3H), 3.33 (d, J = 5.1 Hz, 1H), 3.27 (m, 1H), 3.15 (s br, 1H), 3.03 (s br, 1H), 2.58 (m, 1H), 1.68 (m, 1H), 1.57 (t, J = 19.3 Hz, 3H), 1.36 (s, 9H), 1.13 (m, 1H), 0.90 (d, J = 7.1 Hz, 3H), 0.86 (t, J = 7.4 Hz, 2H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −94.78 (dd, J = 248.7, 9.1 Hz, 1F), −97.99 (ddd, J = 248.7, 18.3, 7.6 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 177.30, 172.54, 137.53, 129.62, 128.78, 127.03, 125.42 (t, J = 241.59 Hz), 65.86, 65.50, 61.69, 56.30, 52.20, 39.74, 39.72, 39.68, 30.03, 28.61, 25.24, 19.49 (t, J = 25.4 Hz), 16.38, 11.83; ESI (m/z) 500.2 [M^++H, (100)], [M^++Na, (11)].

11p: R_f = 0.35 (hexane:AcOEt 8:2); $[\alpha]_D^{20} = +9^\circ$ (c = 1.1, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ = 7.4–7.1 (m, 10H), 5.52 (br s, 1H), 5.11 (d, J = 12.3 Hz, 1H), 5.00 (d, J = 12.3 Hz, 1H), 4.56 (br s, 1H), 3.49 (dt, J = 13.6, 4.3 Hz, 1H), 3.39 (m, 1H), 3.25 (d, J = 3.7 Hz, 1H), 3.19 (dd, J = 13.7, 5.9 Hz, 1H), 3.06 (br m, 1H), 2.94 (br m, 1H), 2.03 (m, 1H), 1.55 (br s, 1H), 1.46 (s, 9H), 0.99 (d, J = 6.8 Hz, 3H), 0.83 (d, J = 6.8, 3H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −60.2 (dd, J = 177.3, 6.0 Hz, 1F), −60.8 (dd, J = 177.3, 8.6 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 175.86, 172.01, 137.08, 136.76, 130.90 (t, J = 296.7 Hz), 129.75, 129.59, 129.19, 128.84 (d, J = 4.2 Hz), 128.45 (d, J = 8.5 Hz), 127.22, 82.63, 67.27, 66.45, 64.11 (t, J = 24.5 Hz), 56.66, 40.10, 40.06, 31.86, 28.48, 19.83, 17.59; ESI (m/z) 582.3 [M^++H, (15)], 604.3 [M^++Na, (100)], 620.2 [M^++K, (23)].

11r: R_f = 0.34 (hexane:AcOEt 8:2): $[\alpha]_D^{20} = -3.4^\circ$ (c = 1.7, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ = 7.35–7.1 (m, 5H), 4.72 (dd, J = 12.7, 3.3 Hz, 1H), 6.97 (s, 1H), 5.17 (s br, 1H), 4.43 (s br, 1H), 3.73 (s, 3H), 3.51 (dt, J = 13.8, 3.9 Hz, 1H), 3.37 (s br, 1H), 3.15 (s br, 1H), 3.02 (s br, 1H), 2.77 (s br, 1H), 1.74 (m, 2H), 1.36 (s, 9H), 1.15 (m, 2H), 0.95 (d, J = 6.7 Hz, 3H), 0.88 (t, J = 7.7 Hz, 3H); ^{19}F NMR (235.4 MHz, $CDCl_3$): δ = −53.3 (d, J = 163.4 Hz, 1F), −53.8 (d, J = 163.4 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 176.77, 172.53, 137.49, 129.81, 129.69, 127.07, 126.18, 123.09 (t, 311.1 Hz), 65.61 (t, J = 25.4 Hz), 56.3, 52.36, 40.61, 39.37, 38.81, 30.04, 28.62, 25.17, 16.42, 11.91, 11.81; ESI (m/z) 564.0 [M^++H, (42)], 586.0 [M^++Na, (100)].

11w: R_f = 0.35 (hexane:AcOEt 85:15); $[\alpha]_D^{20} = +12.3^\circ$ (c = 3.3, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ = 7.4–7.1 (m, 15H), 5.43 (br s, 1H), 5.11 (d, J = 12.4 Hz, 1H), 5.00 (d, J = 12.4 Hz, 1H), 4.49 (br s, 1H), 3.63 (dt, J = 13.9, 4.4 Hz, 1H), 3.31 (m, 1H), 3.13 (dd, J = 6, 13.7 Hz, 1H), 3.19 (dd, J = 13.7, 5.9 Hz, 1H), 3.00 (br m, 2H), 2.93 (dd, J = 13.7, 6 Hz, 1H), 2.93 (dd, J = 13.7, 7 Hz, 1H), 1.58 (br s, 1H), 1.41 (s, 9H); ^{19}F NMR (470.6 MHz, $CDCl_3$): δ = −82.0 (s, 1F), −143.7 (dd, J = 277.7, 12.9 Hz, 1F), −121.9 (dd, J = 277.7, 9.7 Hz, 1F); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 174.99, 171.81, 156.12, 137.66, 137.10, 136.84, 129.71, 128.89, 128.47, 128.38, 127.37, 127.24, 119.47 (qt, J = 286.53, 35.6 Hz), 114.94 (tq, J = 257.7, 36.4 Hz), 67.38, 61.74, 57.92 (t, J = 22.4 Hz), 57.26, 56.66, 40.99, 40.18, 39.14, 38.46, 28.19; ESI (m/z) 664.1 [M^++H, (32)], 686.1 [M^++Na, (100)], 702.1 [M^++K, (5)].

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