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Diastereoselective Addition of Organomagnesium and Organolithium Reagents to Chiral Trifluoromethyl *N*-*tert*-Butanesulfinyl Hemiaminals

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The asymmetric synthesis of trifluoromethylated tertiary and secondary carbinamines (α,α-dibranched and α-branched amines) was achieved by reaction of alkyl, aryl and allyl organomagnesium or organolithium reagents to trifluoromethyl *N*-*tert*-butanesulfinyl hemiaminals, bench-stable analogs of the corresponding ketoimines.

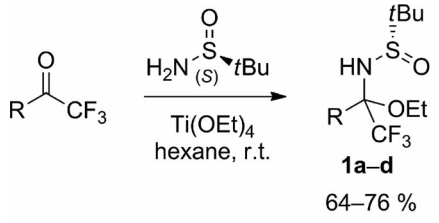
Introduction

Organofluorine compounds have found a wide range of applications as pharmaceuticals, agrochemicals or materials due to the beneficial properties of fluorine.[1] In drug design, the selective incorporation of fluorinated substituents into organic molecules is a well-established strategy by which to modulate biological properties.[2] Among the fluorinated motifs, α-trifluoromethylated amines are highly popular[3] due to the strongly electron-withdrawing nature of the fluorine atom which attenuates the basicity of the adjacent amine functionality. Moreover, the trifluoromethyl group may improve the metabolic stability, increase the bioavailability and/or decrease the toxicity of biologically interesting compounds.[2] As such, the development of asymmetric syntheses of α-trifluoromethylated amines has gained considerable attention over the past several years.[4] A variety of methods have been described for the preparation of secondary carbinamines (α-branched amines) from trifluoromethylated synthons (addition of organometallic reagents to aldimine derivatives,[5] reduction[6] or transamination reactions[7] of ketoimines, and others[8]) or by direct nucleophilic trifluoromethylation[9] of aldimines. However, far fewer studies have been reported for the asymmetric synthesis of trifluoromethylated tertiary carbinamines (α,α-dibranched amines). To date, due to the lack of general methods for nucleophilic trifluoromethylation of ketoimines,[10] all strategies are based on the addition of organometallic reagents on trifluoromethylated oxazolidines or ketoimines derivatives.[11,12]

In this paper, we report our efforts to develop the nucleophilic addition of alkyl and aryl organomagnesium and organolithium reagents to trifluoromethyl *N*-*tert*-butanesulfinyl hemiaminals derived ketoimines. This constitutes an approach complementary to the diastereoselective synthesis of trifluoromethyl-substituted α,α-dibranched and α-branched amines.

Results and Discussion

Chiral aryl and alkyl trifluoromethyl *N*-*tert*-butanesulfinyl ketoimines are known to have a low hydrostability and therefore must be generated quickly prior to use.[13] Consequently, we recently reported the synthesis of the (S_S)-hemiaminals **1a**–**d**,[14] their bench-stable surrogates, to circumvent these problems. (Scheme 1).



1a R = Ph (*dr* = 74:26)
1b R = 4-FC_6H_4 (*dr* = 64:36)
1c R = 3-$MeOC_6H_4$ (*dr* = 57:43)
1d R = Me (*dr* = 100:0)

Scheme 1. Synthesis of chiral trifluoromethyl (*S*)-*N*-*tert*-butanesulfinyl hemiaminals.[14]

To determine the optimal conditions for asymmetric synthesis of trifluoromethyl tertiary carbinamines, we examined the reaction of phenyl hemiaminal **1a** with 2 equiv. of methylmagnesium chloride (in THF) or methyllithium (in Et_2O) in various solvents and at different temperatures

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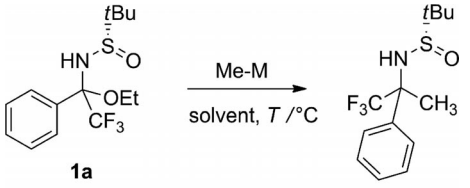
(Table 1). With methylmagnesium chloride (Table 1, Entries 1–5), the best diastereoselectivity (30:70), though moderate, was obtained using either toluene or CH_2Cl_2 at room temperature (Table 1, Entries 2 and 4). For practical reasons, this last solvent was selected for further scope and limitation studies with organomagnesium reagents. With methyllithium (Table 1, Entries 6–9) the best diastereoselectivity and yield were observed when performing the reaction in toluene from –78 °C to 0 °C (Table 1, Entry 8). Although the diastereoselectivity of the addition was slightly greater when using methyllithium instead of the Grignard reagent (25:75 instead of 30:70), no reversal of induction was observed,[15,16] (Table 1, Entries 4 and 8).

Table 1. Optimization of reaction conditions for additions of methylmagnesium chloride or methyllithium to phenyl hemiaminal **1a**.

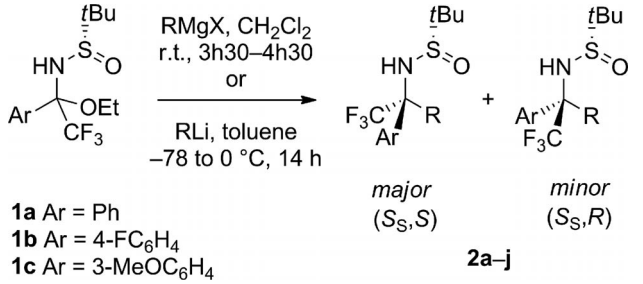


Entry	Me-M[a]	Solvent	T [°C]	dr[b]	Yield [%][c]
1	MeMgCl	Me-THF	r.t.	39:61	62
2	MeMgCl	toluene	r.t.	30:70	72
3	MeMgCl	toluene	–10	30:70	75
4	MeMgCl	CH_2Cl_2	r.t.	30:70[d]	75
5	MeMgCl	CH_2Cl_2	–10	33:67	71
6	MeLi	toluene	–78	–[e]	–
7	MeLi	toluene	–25	34:66	63
8	MeLi	toluene	–78–0	25:75	77
9	MeLi	CH_2Cl_2	–78–0	–[f]	–

[a] All reactions were performed with 2 equiv. of organometallic reagent. [b] Diastereomeric ratio (*dr*) determined by ^{19}F NMR of the crude mixture. [c] Isolated yield of both diastereomers after silica gel purification. [d] Starting from a diastereomerically pure sample of **1a** led to the same diastereomeric ratio. [e] Very complex crude mixture containing ca. 25% of tertiary amine **2a** (*dr* = 23:77) and ca. 60% of starting hemiaminals **1a** according to the ^{19}F NMR spectroscopy. [f] Very messy crude mixture, only traces of tertiary sulfinamide **2a** were detected by ^{19}F NMR spectroscopy.

The diastereoselective additions of methyl, benzyl, 2-thienyl and allylic organomagnesium halides and methyllithium to trifluoromethyl aryl *N*-*tert*-butanesulfinyl hemiaminals **1a**–**c** were then screened using the optimized reaction conditions (organomagnesium halide in CH_2Cl_2 at room temp. or organolithium in toluene from –78 to 0 °C). The results are depicted in Table 2. Although the addition of methyl organometallic reagents and of benzyl and 2-thienyl Grignard reagents occurred with poor to moderate diastereoselectivity (*dr* ranging from 39:61 to 25:75), amines **2a**–**c**, **f**, **h** were isolated in good yields (69–89%) (Table 2, Entries 1, 3, 4, 7 and 10). It is worth noting that with all aryl hemiaminals **1a**–**c**, the diastereomeric ratio was slightly enhanced when using methyllithium relative to the methyl Grignard reagent (Table 2, Entries 1, 2, 7, 8 and 10, 11). As previously noticed,[15a,16] the allylation was much more successful than was addition of other organomagnesium reagents; homoallylic tertiary sulfinamides **2d**, **e**, **g**, **i**, **j** were obtained with the highest diastereomeric ratios (from 9:91 to 5:95) (Table 2, Entries 5, 6, 9, 12, 13).

Table 2. Reaction of aryl hemiaminals **1a**–**c** with methyl, benzyl, 2-thienyl, allyl organomagnesium halides and methyllithium reagents.



Entry	Substrate	RMgX or RLi[a]	Product	dr[b] (S_S,R):(S_S,S)	Yield [%][c]
1	**1a**	MeMgCl	**2a**	30:70	75
2	**1a**	MeLi	**2a**	25:75	77
3	**1a**	BnMgCl	**2b**	29:71	69
4	**1a**	2-ThienylMgBr	**2c**	27:73	71
5	**1a**	AllylMgCl	**2d**	8:92	83
6	**1a**	2-Methyl-allylMgCl	**2e**	9:91	70
7	**1b**	MeMgCl	**2f**	39:61	79
8	**1b**	MeLi	**2f**	31:69	82
9	**1b**	AllylMgCl	**2g**	8:92	67
10	**1c**	MeMgCl	**2h**	35:65	69
11	**1c**	MeLi	**2h**	32:68	74
12	**1c**	AllylMgCl	**2i**	9:91	65
13	**1c**	2-Methyl-allylMgCl	**2j**	5:95	64

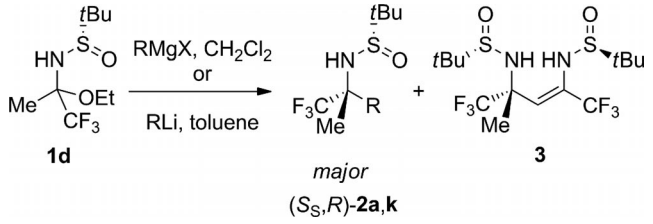
[a] All reactions were performed with 2 equiv. of organometallic reagent. [b] Diastereomeric ratio (*dr*) determined by ^{19}F NMR of the crude mixture. [c] Isolated yield of both diastereomers of sulfinamides **2** after silica gel purification.

The absolute configuration of the newly created stereocenter of *N*-protected tertiary carbinamines (S_S,R)-**2a** and (S_S,S)-**2a** was unequivocally assigned by cleaving the sulfinamide with HCl and examining the optical rotation of the known salts (see Supporting Information for details).[12b,17]

The nucleophilic addition of organomagnesium and organolithium reagents was next explored with heminaminal **1d** bearing a methyl substituent (Table 3). Reaction of phenylmagnesium bromide under the previously optimized reaction conditions afforded a complex mixture from which protected amine **2a** was isolated with a poor yield (35%) albeit with a very a high diastereoselectivity [93:7, in favour of the (S_S,R) isomer] along with product **3**[18] (Table 3, Entry 1). Bis-trifluoromethylated compound **3** results from the self-condensation[19] of the intermediate methyl ketoimine and further tautomerization towards the more stable enamine. Lowering the temperature of the organomagnesium reaction to –20 °C or performing the reaction with phenyllithium decreased the amount of **3** and increased slightly the facial diastereoselectivity for the addition of the organometallic reagent. Using phenyllithium as the nucleophile, protected amine **2a** was obtained with a diastereomeric ratio of 99:1 (Table 3, Entries 2 and 3). When $AlMe_3$ was used

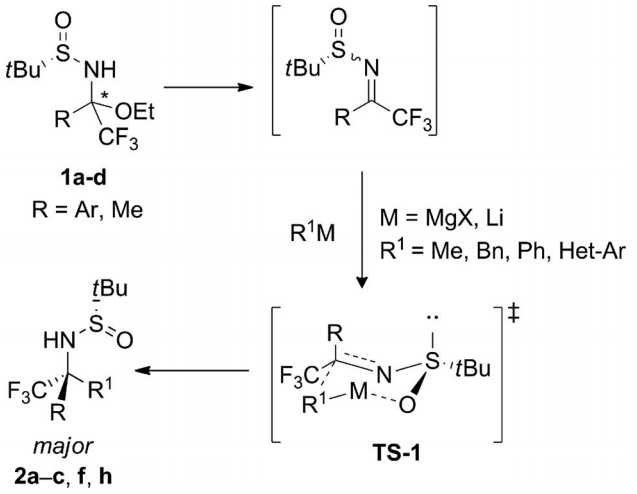
as an additive with phenyllithium,[15] a much cleaner crude mixture was obtained (according to the ^{19}F and ^{1}H NMR spectra) but the yield of amines **2a** was not improved and the diastereoselectivity was lowered (Table 3, Entry 4). Finally, reaction of hemiaminal **1d** with allylmagnesium chloride at –20 °C afforded the homoallylic amines **2k** with a good diastereoselectivity (89:11) and moderate yield (42%) (Table 3, Entry 5).

Table 3. Reactions of methyl hemiaminal **1d** with organomagnesium and organolithium reagents.

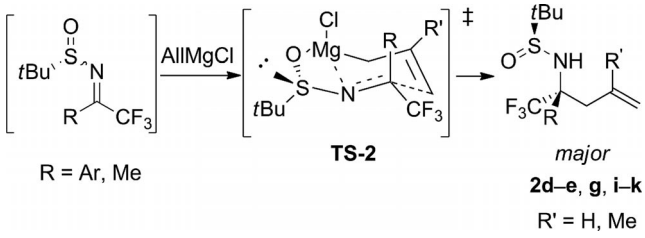


Entry	Nu[a]	T [°C]	dr[b] of **2**(S_S,R):(S_S,S)	Yield of **2**[%][c]	Yield of **3** [%][d]
1	PhMgBr	r.t.	93:7	**2a**, 35	18
2	PhMgBr	–20	95:5	**2a**, 36	9
3	PhLi	–78–0	99:1	**2a**, 44	9
4	PhLi + $AlMe_3$[e]	–78–0	83:17	**2a**, 44	–
5	AllylMgCl	–20	89:11	**2k**, 42	5

[a] All reactions were performed with 2 equiv. of organometallic nucleophile (Nu). [b] Diastereomeric ratio (dr) determined by ^{19}F NMR of the crude mixture. [c] Isolated yield of both diastereomers after silica gel purification. [d] After silica gel purification, only one diastereomer of product **3** was detected by ^{19}F NMR spectroscopy. [e] A solution of $AlMe_3$ (1.1 equiv.) and hemiaminal **1d** in toluene was stirred 20 min before the addition of PhLi.



Scheme 2. Rationalization of the observed diastereoselectivity for the alkylation reactions with organometallic reagents.



Scheme 3. Rationalization of the observed diastereoselectivity for the allylation reaction.

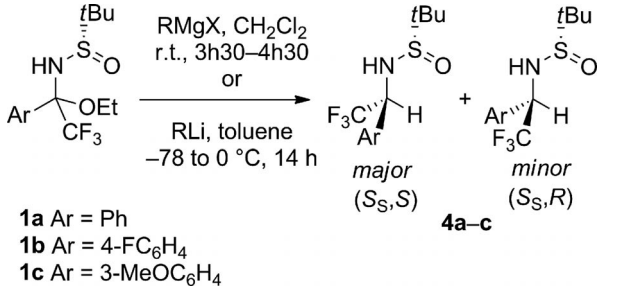
The observed diastereoselectivity for the addition of methyl, benzyl, aryl and heteroaryl organomagnesium or organolithium reagent is consistent with a Zimmerman–Traxler-type six-membered transition-state **TS-1** with coordination of the sulfinyl oxygen of the intermediate imine[14] to the metal[16] (Scheme 2). In this six-membered chair transition state the trifluoromethyl group prefers to occupy the equatorial position rather than the axial one due to steric hindrance and to the electrostatic repulsion between the trifluoromethyl group and the lone pair electrons of the sulfur group.[6c,11b,14,20] Consequently, approach of the organometallic reagent occurs by the *re* face.

The same facial diastereoselectivity, though greater for the allylation reaction relative to the alkylation with Grignard reagents, can be explained by a chelated transition-state model **TS-2** (Scheme 3).[15a,16,21] In this cyclic transition state where both the sulfinyl oxygen and the imine nitrogen are coordinated to the magnesium, the approach of the allyl Grignard reagent occurs also from the *re* face.

The reaction of hemiaminals **1a**–**c** with ethyl, isopropyl and *n*-butylmagnesium halides generated only secondary trifluoromethylated carbinamines **4a**–**c**, resulting from the reduction of the intermediate imines[14] via *β*-hydride transfer (Table 4). The secondary carbinamines **4a**–**c** were isolated in good yields and, more importantly, with very high diastereoselectivity (from 4:96 to 2:98) (Table 4, Entries 1, 3, 4, 6, 7). The high facial stereoselectivity for reduction of **1a** with Grignard reagent is comparable to that observed for the reduction of the trifluoromethyl phenyl ketoimine with borohydride reagents.[6d] Performing the reaction of hemiaminal **1a** with zincate complex at –78 °C or –20 °C to favour the ethyl transfer and to avoid the reduction side reaction[22] proved futile (Table 4, Entry 2). Reaction of hemiaminal **1a** with *n*BuLi gave secondary carbinamine **4a** albeit in poor yield, due to the formation of a complex mixture, and with a diastereomeric ratio slightly lower than the one observed with Grignard reagent (Table 4, Entries 4 and 5).

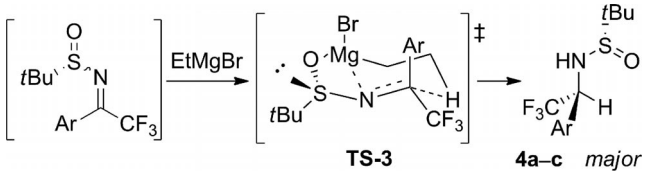
The absolute configuration of the newly created stereocenter of secondary *N*-protected sulfinamide (S_S,S)-**4a** was unequivocally assigned by cleaving the sulfinamide with HCl and examining the optical rotation of the known salt (see Supporting Information for details).[5e,6d,9a,17] A six-membered ring transition-state **TS-3** where the sulfinyl oxygen and the imine nitrogen are both coordinated to the magnesium can be invoked to rationalize the high facial diastereoselectivity for the reduction by organometallics by *β*-hydride elimination (Scheme 4).

Table 4. Reductions of aryl hemiaminals **1a**–**c** with ethyl, isopropyl, *n*-butyl organomagnesium halides and *n*-butyllithium reagents.



Entry	Substrate	Nu[a]	Product	*dr*[b] (S_S,*R*):(S_S,*S*)	Yield [%][c]
1	**1a**	EtMgBr	**4a**	2:98	79
2	**1a**	EtMgBr + Me_2Zn[d]	–	–	–
3	**1a**	*i*PrMgCl	**4a**	4:96	80
4	**1a**	*n*BuMgCl	**4a**	4:96	83
5	**1a**	*n*BuLi	**4a**	5:95	37
6	**1b**	EtMgBr	**4b**	4:96	72
7	**1c**	EtMgBr	**4c**	2:98	73

[a] All reactions were performed with 2 equiv. of organometallic nucleophile (Nu) . [b] Diastereomeric ratio (*dr*) determined by ^{19}F NMR of the crude mixture. [c] Isolated yield of both diastereomers of sulfinamides **4** after silica gel purification. [d] The reaction was attempted at –78 °C and at –20 °C in the presence of Me_2Zn (2.5 equiv.). After 7 h of stirring at –78 °C, very complex crude mixture containing ca. 50% of starting hemiaminal, ca. 40% of tertiary amines (*dr* = 40:60) and traces of secondary amines, according to the ^{19}F NMR, which could not be separated by chromatography on silica gel. After 7 h of stirring at –20 °C, very complex crude mixture containing ca. 40% of tertiary amines (*dr* = 33:67) and ca. 25% of secondary amines (*dr* > 99:1), according to the ^{19}F NMR, which could not be separated by chromatography on silica gel.



Scheme 4. Transition state proposed for the reduction.

Conclusions

We have shown that the reaction of organomagnesium halides and organolithium with chiral trifluoromethyl *N*-sulfinyl hemiaminals, bench-stable surrogates of the corresponding ketoimines, led to the *N*-protected amines with moderate to excellent diastereomeric ratio (*dr* up to 99:1). The best yields were obtained from aryl hemiaminals due to competitive side reactions with methyl hemiaminals. Reaction of aromatic hemiaminals with allylic Grignard reagents gave the trifluoromethyl tertiary carbinamines with the best diastereoselectivities (*dr* up to 95:5). Ethyl, isopropyl and *n*-butyl Grignard reagents all afforded secondary carbinamines with very high diastereoselectivities (*dr* ranging from 96:4 to 98:2).

Experimental Section

Generals: CH_2Cl_2 (extra-dry, water < 0.003%), toluene (extra-dry, on molecular sieves) and 2-Me-THF (extra-dry, water < 0.005%, on molecular sieves) were purchased from Acros Organics. All Grignard reagents were purchased from Aldrich or Acros Organics and were titrated through the combined use of (+)-menthol and (1,10)-phenanthroline as indicator.[23] Organolithium reagents were purchased from Acros Organics and were titrated using *N*-pivaloyl-*o*-toluidine as indicator.[24] Thin-layer chromatography using precoated aluminium backed plates (Merck Kieselgel 60F254) were visualized by UV light and/or by phosphomolybdic acid. Flash chromatography was performed with silica gel 15–40 μm (Merck) and an Armen flash pump. NMR spectra were recorded in $CDCl_3$ with 250 MHz and 500 MHz spectrometers. Chemicals shifts (δ) are reported in ppm relative to TMS for ^1H and ^{13}C NMR spectra and to $CFCl_3$ for ^{19}F NMR spectra. In the ^{13}C NMR spectroscopic data, reported signal multiplicities are related to C-F coupling. The following abbreviations are used to indicate the multiplicities: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet). Diastereomeric ratios (*dr*) were determined by ^{19}F NMR spectroscopy. HRMS were recorded with an ESI-Q-TOF mass spectrometer using an electrospray source in positive mode. Melting points (m.p.) were determined using a Tottoli apparatus. Optical rotations were measured at room temperature (ca. 20 °C).

General Procedure A: Reaction of Organomagnesium Reagents with Hemiaminals 1a–d: The organomagnesium reagent (2 equiv.) was added under Ar at 0 °C (for aromatic hemiaminals **1a**–**c**) or –20 °C (for methyl hemiaminal **1d**) to a solution of hemiaminal **1a**–**d** in CH_2Cl_2. The reaction was stirred at room temp. (for aromatic hemiaminals **1a**–**c**) or –20 °C (for methyl hemiaminal **1d**) until completion and then hydrolyzed with a sat. aq. sol. of NH_4Cl. The aqueous layer was extracted twice with CH_2Cl_2. The organic layers were combined, washed with a sat. aq. sol. of $NaHCO_3$ and brine, dried (Na_2SO_4), filtered and concentrated under reduced pressure. The residue was purified by chromatography on silica gel.

General Procedure B: Reaction of Organolithium Reagents with Hemiaminals 1a–d: The organolithium reagent (2 equiv.) was added under Ar at –78 °C to a solution of hemiaminal **1a**–**d** in toluene. The reaction mixture was then slowly raised to 0 °C during 14 h and then hydrolyzed with a sat. aq. sol. of NH_4Cl. The aqueous layer was extracted twice with Et_2O. The organic layers were combined, washed with brine, dried (Na_2SO_4), filtered and concentrated under reduced pressure. The residue was purified by chromatography on silica gel.

(+)-(S_S,*R*)-2-Methyl-*N*-(1,1,1-trifluoro-2-phenylpropan-2-yl)-propane-2-sulfinamide [(S_S,*R*)-2a], (+)-(S_S,*S*)-2-Methyl-*N*-(1,1,1-trifluoro-2-phenylpropan-2-yl)propane-2-sulfinamide [(S_S,*S*)-2a] and (–)-(S_S,S_S)-*N*,*N*′-[(*R*,*Z*)-1,1,1,5,5,5-hexafluoro-4-methylpent-2-ene-2,4-diyl]bis(2-methylpropane-2-sulfinamide) (3): *Reaction of phenyl hemiaminal* **1a** *with methyl Grignard reagent*: Following the general procedure A, a solution of methylmagnesium chloride (2.45*M in* THF, 747 μL, 1.83 mmol) was added to a solution of hemiaminal **1a** (296 mg, 0.915 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 30:70] on silica gel (petroleum ether/Et_2O, 70:30) afforded sulfinamide (S_S,*R*)-**2a** (57 mg, 21%) as a colorless oil, an intermediate fraction

containing a mixture of both isomers of **2a** (10 mg, 4%), and sulfinamide (S_S,*S*)-**2a** (133 mg, 50%) as a white solid. *Reaction of phenyl hemiaminal* **1a** *with methyllithium*: Following the general procedure B, a solution of methyllithium (0.86*M in* Et_2O, 2.30 mL, 1.97 mmol) was added to a solution of hemiaminal **1a** (349 mg, 0.987 mmol) in toluene (8 mL). Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 25:75] on silica gel (petroleum ether/Et_2O, 70:30) afforded sulfinamide (S_S,*R*)-**2a** (55 mg, 19%) as a colorless oil, an intermediate fraction containing a mixture of both isomers of **2a** (12 mg, 4%), and sulfinamide (S_S,*S*)-**2a** (156 mg, 54%) as a white solid. *Reaction of methyl hemiaminal* **1d** *with phenyl Grignard reagent*: Following the general procedure A, a solution of phenylmagnesium bromide (1.95*M in* Et_2O, 883 μL, 1.72 mmol) was added to a solution of hemiaminal **1d** (225 mg, 0.361 mmol) in CH_2Cl_2 (5 mL). Purification of the residue [**2a** *dr* (S_S,*R*):(S_S,*S*) = 95:5] on silica gel (petroleum ether/Et_2O 90 to, 70:30) afforded bis-sulfinamide **3** (16 mg, 9%) as a colorless oil, sulfinamide (S_S,*R*)-**2a** (86 mg, 34%) as a colorless oil, and sulfinamide (S_S,*S*)-**2a** (5 mg, 2%) as a white solid. *Reaction of methyl hemiaminal* **1d** *with phenyllithium*: Following the general procedure B, a solution of phenyllithium (0.90*M in* nBu_2O, 2.14 mL, 1.92 mmol) was added to a solution of hemiaminal **1d** (251 mg, 0.961 mmol) in toluene (8 mL). Purification of the residue [**2a** *dr* (S_S,*R*):(S_S,*S*) = 99:1] on silica gel (petroleum ether/Et_2O, 90:10 to 70:30) afforded bis-sulfinamide **3** (18 mg, 9%) as a colorless oil and sulfinamide (S_S,*R*)-**2a** (123 mg, 44%) as a colorless oil. (S_S,*R*)-**2a**: $[\alpha]_D^{20}$ = +48.8 (*c* = 0.66, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2690, 1500, 1274, 1156, 1072, 700 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –77.3 (s, CF_3) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.24 (s, 9 H), 1.93 (s, 3 H), 3.97 (s, 1 H), 7.32 (d, *J* = 7.0 Hz, 1 H), 7.36 (dd, *J* = 7.0, 8.5 Hz, 2 H), 7.58 (d, *J* = 8.0 Hz, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 21.5, 22.5, 56.7, 63.8 (q, *J* = 27.5 Hz), 125.9 (q, *J* = 285.0 Hz), 126.7, 128.7, 138.8 ppm. HRMS: *m*/*z* calcd. for $C_{13}H_{18}F_3NaNOS$ $[M + Na]^+$ 316.0959, found 316.0959. (S_S,*S*)-**2a**: M.p. 73–74 °C. $[\alpha]_D^{20}$ = +97.3 (*c* = 1.03, $CHCl_3$). IR (KBr$\tilde{\nu}$ = 2974, 1449, 1274, 1156, 700 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –78.5 (s, CF_3) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.12 (s, 9 H), 1.86 (s, 3 H), 3.76 (s, 1 H), 7.29 (m, 3 H), 7.47 (d, *J* = 7.5 Hz, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.3, 22.7, 56.7, 63.5 (q, *J* = 27.5 Hz), 125.6 (q, *J* = 285.0 Hz), 128.2, 128.8, 135.3 ppm. HRMS: *m*/*z* calcd. for $C_{13}H_{18}F_3NaNOS$ $[M + Na]^+$ 316.0959, found 316.0958. **3**: M.p. 103–105 °C. $[\alpha]_D^{20}$ = –36.0 (*c* = 0.52, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2360, 1367, 1272, 1174, 1140, 1062 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –71.2 (s, 3 F, CF_3), –80.2 (s, 3 F, CF_3) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.29 (s, 18 H), 1.67 (s, 3 H), 6.26 (s, 1 H), 6.65 (s, 1 H), 7.60 (s, 1 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 21.3, 22.8, 23.1, 57.5, 57.8, 61.4 (q, *J* = 28.0 Hz), 121.2 (q, *J* = 275.0 Hz), 124.9 (q, *J* = 285.0 Hz), 128.4 (q, *J* = 3.5 Hz), 131.5 (q, *J* = 32.0 Hz) ppm. HRMS: *m*/*z* calcd. for $C_{14}H_{24}F_6NaN_2O_2S_2$ $[M + Na]^+$ 453.1081, found 453.1062. A small amount has been recrystallized from Et_2O/petroleum ether for X-ray analysis.

(*S*$_S$)-2-Methyl-*N*-(1,1,1-trifluoro-2,3-diphenylpropan-2-yl)propane-2-sulfinamide (2b): Following the general procedure A, a solution of benzylmagnesium chloride (1.0 M in Et_2O, 1.78 mL, 1.78 mmol) was added to a solution of hemiaminal **1a** (287 mg, 0.888 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 29:71] on silica gel (petroleum ether/Et_2O, 85:15) afforded a mixture of sulfinamides (S_S,*R*)-**2b** and (S_S,*S*)-**2b** (226 mg, 69%) as a colorless oil. IR (film): $\tilde{\nu}$ = 2960, 1166, 1078, 702 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –69.5 (s, CF_3 *minor*), –71.5 (s, CF_3 *major*) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.25 (s, 3 H, *major*), 1.30 (s, 3 H, *minor*), 3.55 (d, *J* = 14.0 Hz, 1 H, *minor*), 3.61 (d, *J* = 14.0 Hz, 1 H, *minor*), 3.64 (s, 2 H, *major*), 4.04 (s, 1 H, *minor*), 4.17 (s, 1 H, *major*), 6,88–7.71 (m, 10 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.7 (*minor*), 22.8 (*major*), 42.6 (*major*), 43.7 (*minor*), 57.5 (*major*), 57.6 (*minor*), 67.1 (q, *J* = 25.5 Hz, *major*), 68.0 (q, *J* = 26.0 Hz, *minor*), 125.7 (q, *J* = 287.0 Hz, *major*), 126.0 (q, *J* = 287.0 Hz, *minor*), 127.3, 127.5, 127.9, 128.0, 128.2, 128.3, 128.4, 128.6, 129.1, 129.2, 131.1 (*minor*), 131.6 (*major*), 133.5 (*minor*), 133.6 (*major*), 134.8 (*major*), 136.6 (*minor*) ppm. HRMS: *m*/*z* calcd. for $C_{19}H_{22}F_3NaNOS$ $[M + Na]^+$ 392.1272, found 392.1266.

(*S*$_S$)-2-Methyl-*N*-[2,2,2-trifluoro-1-phenyl-1-(thiophen-2-yl)ethyl]-propane-2-sulfinamide (2c): Following the general procedure A, a solution of 2-thienylmagnesium bromide (0.5*M in* THF, 3.58 mL, 1.79 mmol) was added to a solution of hemiaminal **1a** (290 mg, 0.896 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 27:73] on silica gel (petroleum ether/Et_2O, 85:15) afforded a mixture of sulfinamides (S_S,*R*)-**2c** and (S_S,*S*)-**2c** (230 mg, 71%) as a beige oil. IR (film): $\tilde{\nu}$ = 1636, 1260, 1164, 1075, 700 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –71.5 (s, CF_3 *minor*), –72.3 (s, CF_3 *major*) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.26 (s, 9 H), 4.40 (s, 1 H), 6.98–7.65 (m, 9 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.7, 57.3 (*major*), 57.6 (*minor*), 68.9 (q, *J* = 28.4 Hz, *minor*), 69.3 (q, *J* = 33.0 Hz, *major*), 125.2 (q, *J* = 286.5 Hz, *minor*), 125.4 (q, *J* = 286.5 Hz, *major*), 126.7 (*minor*), 126.9 (*major*), 127.6 (*minor*), 127.7 (*major*), 128.3 (*minor*), 128.4 (*major*), 128.6 (d, *J* = 2.0 Hz, *major*), 128.9 (d, *J* = 2.0 Hz, *minor*), 129.3 (*major*), 129.4 (*minor*), 129.9 (d, *J* = 1.5 Hz, minor), 130.7 (d, *J* = 1.5 Hz, *major*), 136.6 (*minor*), 137.5 (*major*), 139.5 (*major*), 141.2 (*minor*) ppm. HRMS: *m*/*z* calcd. for $C_{16}H_{18}F_3NaNOS_2$ $[M + Na]^+$ 384.0680, found 384.0690.

(+)-(*S*$_S$,*S*)-2-Methyl-*N*-(1,1,1-trifluoro-2-phenylpent-4-en-2-yl)-propane-2-sulfinamide [(*S*$_S$,*S*)-2d]: Following the general procedure A, a solution of allylmagnesium chloride (1.71*M in* THF, 1.22 mL, 2.08 mmol) was added to a solution of hemiaminal **1a** (337 mg, 1.04 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 8:92] on silica gel (petroleum ether/Et_2O, 80:20) afforded a mixture of sulfinamides (S_S,*R*)-**2d** and (S_S,*S*)-**2d** (129 mg, 39%), and sulfinamide (S_S,*S*)-**2d** (147 mg, 44%) as a colorless oil. (S_S,*S*)-**2d**: $[\alpha]_D^{20}$ = +30.0 (*c* = 1.07, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2961, 1500, 1158, 1069, 703 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –73.6 (s, CF_3) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.25 (s, 9 H), 3.06 (dd, *J* = 7.5, 14.5 Hz, 1 H), 3.14 (dd, *J* = 7.0, 14.5 Hz, 1 H), 4.12 (s, 1 H), 5.20 (d, *J* = 10.5 Hz, 1 H), 5.27 (dd, *J* = 1.5, 17.5 Hz, 1 H), 5.63 (ddd, *J* = 7.0, 10.5, 17.5 Hz, 1 H), 7.39 (m, 3 H), 7.59 (d, *J* = 7.5 Hz, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.8, 40.0, 57.5, 65.9 (d, *J* = 26.0 Hz), 121.7, 125.7 (q, *J* = 287.0 Hz), 128.4, 129.0, 130.8, 134.9 ppm. HRMS: *m*/*z* calcd. for $C_{15}H_{20}F_3NaNOS$ $[M + Na]^+$ 342.1115, found 342.1126.

(*S*$_S$)-2-Methyl-*N*-(1,1,1-trifluoro-4-methyl-2-phenylpent-4-en-2-yl)-propane-2-sulfinamide (2e): Following the general procedure A, a solution of 2-methylallylmagnesium chloride (0.44*M in* THF, 4.49 mL, 1.97 mmol) was added to a solution of hemiaminal **1a** (319 mg, 0.987 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 9:91] on silica gel (petroleum ether/Et_2O, 80:20) afforded a mixture of sulfinamides (S_S,*R*)-**2e** and (S_S,*S*)-**2e** (231 mg, 70%) as a colorless oil. IR (film): $\tilde{\nu}$ = 2961, 1390, 1156, 1075, 700 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –71.3 (s, CF_3 *minor*), –72.6 (s, CF_3 *major*) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.24 (s, 9 H, *major*), 1.25 (s, 9 H, *minor*), 1.42 (s, 3 H), 2.95 (d, *J* = 14.0 Hz, 1 H, *major*), 2.96 (d, *J* = 14.0 Hz, 1 H, *minor*), 3.05 (d, *J* = 14.5 Hz, 1 H, *major*), 3.11 (d, *J* = 14.5 Hz, 1 H, *minor*), 4.03 (s, 1 H, *minor*), 4.31 (s, 1 H, *major*),

4.60 (s, 1 H, *minor*), 4.84 (s, 1 H, *major*), 4.87 (s, 1 H, *minor*), 4.96 (s, 1 H, *major*), 7.35 (m, 3 H), 7.59 (d, J = 7.5 Hz, 2 H, *minor*), 7.67 (d, J = 8.0 Hz, 2 H, *major*) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.5 (*major*), 22.7 (*minor*), 43.7 (*major*), 43.9 (*minor*), 57.4 (*minor*), 57.6 (*major*), 66.1 (q, J = 26.0 Hz, *major*), 117.5 (*minor*), 118.5 (*major*), 125.7 (q, J = 287.0 Hz, *major*), 128.3 (*major*), 128.4 (d, J = 1.5 Hz, *major*), 128.8 (*major*), 135.5 (*major*), 137.0 (*minor*), 138.7 (*minor*), 139.0 (*major*) ppm. HRMS: *m*/*z* calcd. for $C_{16}H_{22}F_3NaNOS$ [M + Na]$^+$ 356.1272, found 356.1264.

(+)-(S_S,*R*)-2-Methyl-*N*-[1,1,1-trifluoro-2-(4-fluorophenyl)propan-2-yl]propane-2-sulfinamide [(S_S,*R*)-2f] and (+)-(S_S,*S*)-2-Methyl-*N*-[1,1,1-trifluoro-2-(4-fluorophenyl)propan-2-yl]propane-2-sulfinamide [(S_S,*S*)-2f]: *Reaction of aryl hemiaminal* **1b** *with methyl Grignard reagent*: Following the general procedure A, a solution of methylmagnesium chloride (2.45*M in* THF, 693 μL, 1.70 mmol) was added to a solution of hemiaminal **1b** (290 mg, 0.850 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 39:61] on silica gel (petroleum ether/Et_2O, 70:30) afforded sulfinamide (S_S,*R*)-**2f** (74 mg, 28%) as a colorless oil, an intermediate fraction containing a mixture of both isomers of **2f** (9 mg, 3%), and sulfinamide (S_S,*S*)-**2f** (127 mg, 48%) as a white solid. *Reaction of aryl hemiaminal* **1b** *with methyllithium*: Following the general procedure B, a solution of methyllithium (0.86*M in* Et_2O, 1.83 mL, 1.57 mmol) was added to a solution of hemiaminal **1b** (268 mg, 0.785 mmol) in toluene (8 mL). Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 31:69] on silica gel (petroleum ether/Et_2O, 70:30) afforded sulfinamide (S_S,*R*)-**2f** (46 mg, 19%) as a colorless oil, an intermediate fraction containing a mixture of both isomers of **2f** (26 mg, 11%), and sulfinamide (S_S,*S*)-**2f** (126 mg, 52%) as a white solid. (S_S,*R*)-**2f**: $[\alpha]_D^{20}$ = +43.0 (c = 0.51, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2960, 1608, 1514, 1274, 1243, 1165, 1071, 838 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –77.7 (s, 3 F, CF_3), –113.5 (m, 1 F, CF) ppm. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.26 (s, 9 H), 1.93 (s, 3 H), 3.91 (s, 1 H), 7.06 (t, J = 8.5 Hz, 2 H), 7.57 (dd, J = 5.0, 8.5 Hz, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 21.7, 22.6, 56.9, 63.7 (q, J = 27.5 Hz), 115.7 (d, J = 21.5 Hz), 125.9 (q, J = 284.5 Hz), 129.0 (dd, J = 1.5, 18.5 Hz), 134.7 (d, J = 3.5 Hz), 162.8 (d, J = 249.0 Hz) ppm. HRMS: *m*/*z* calcd. for $C_{13}H_{17}F_4NaNOS$ [M + Na]$^+$ 334.0865, found 334.0860. (S_S,*S*)-**2f**: M.p. 93–94 °C. $[\alpha]_D^{20}$ = +97.0 (c = 0.50, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2961, 1515, 1171, 1155, 1135, 1018, 836 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –78.9 (s, 3 F, CF_3), –112.8 (m, 1 F, CF) ppm. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.23 (s, 9 H), 1.96 (s, 3 H), 3.73 (s, 1 H), 7.07 (t, J = 8.5 Hz, 2 H), 7.54 (dd, J = 5.5, 8.5 Hz, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.6, 23.2, 57.1, 63.5 (q, J = 27.5 Hz), 115.4 (d, J = 21.5 Hz), 125.7 (q, J = 285.0 Hz), 130.7 (dd, J = 1.0, 8.5 Hz), 131.1 (d, J = 3.5 Hz), 163.1 (d, J = 249.5 Hz) ppm. HRMS: *m*/*z* calcd. for $C_{13}H_{17}F_4NaNOS$ [M + Na]$^+$ 334.0865, found 334.0866.

(+)-(S_S,*S*)-2-methyl-*N*-[1,1,1-trifluoro-2-(4-fluorophenyl)pent-4-en-2-yl]propane-2-sulfinamide [(S_S,*S*)-2 g]: Following the general procedure A, a solution of allylmagnesium chloride (1.71*M in* THF, 898 μL, 1.34 mmol) was added to a solution of hemiaminal **1b** (262 mg, 0.767 mmol) in CH_2Cl_2 (7 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 8:92] on silica gel (petroleum ether/Et_2O, 80:20) afforded a mixture of sulfinamides (S_S,*R*)-**2g** and (S_S,*S*)-**2g** (30 mg, 12%), and sulfinamide (S_S,*S*)-**2g** (142 mg, 55%) as a pale yellow oil. (S_S,*S*)-**2g**: $[\alpha]_D^{20}$ = +35.9 (c = 1.01, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2962, 1515, 1241, 1163, 1045, 839 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –73.7 (s, 3 F, CF_3), –113.0 (m, 1 F, CF) ppm. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.22 (s, 9 H), 3.00 (dd, J = 7.5, 15.0 Hz, 1 H), 3.08 (dd, J = 7.0, 14.5 Hz, 1 H), 4.12 (s, 1 H), 5.21 (d, J = 10.0 Hz, 1 H), 5.26 (d, J = 17.0 Hz, 1 H), 5.63 (ddd, J = 7.5, 10.0, 17.0 Hz, 1 H), 7.05 (t, J = 8.5 Hz, 2 H), 7.57 (dd, J = 5.0, 8.5 Hz, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.7, 40.4, 57.4, 65.6 (q, J = 26.0 Hz), 115.3 (d, J = 21.5 Hz), 122.1, 125.6 (q, J = 287.0 Hz), 130.5, 130.7 (d, J = 8.5 Hz), 162.8 (d, J = 249.5 Hz) ppm. HRMS: *m*/*z* calcd. for $C_{15}H_{19}F_4NaNOS$ [M + Na]$^+$ 360.1021, found 360.1018.

(+)-(S_S,*R*)-2-Methyl-*N*-[1,1,1-trifluoro-2-(3-methoxyphenyl)-propan-2-yl]propane-2-sulfinamide [(S_S,*R*)-2h] and (+)-(S_S,*S*)-2-Methyl-*N*-[1,1,1-trifluoro-2-(3-methoxyphenyl)propan-2-yl]-propane-2-sulfinamide [(S_S,*S*)-2h]: *Reaction of aryl hemiaminal* **1c** *with methyl Grignard reagent*: Following the general procedure A, a solution of methylmagnesium chloride (2.45*M in* THF, 726 μL, 1.78 mmol) was added to a solution of hemiaminal **1c** (314 mg, 0.890 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 35:65] on silica gel (petroleum ether/Et_2O, 70:30) afforded sulfinamide (S_S,*R*)-**2h** (71 mg, 25%) as a white solid, and sulfinamide (S_S,*S*)-**2h** (128 mg, 44%) as a pale yellow solid. *Reaction of aryl hemiaminal* **1c** *with methyllithium*: Following the general procedure B, a solution of methyllithium (0.86*M in* Et_2O, 2.03 mL, 1.75 mmol) was added to a solution of hemiaminal **1c** (308 mg, 0.873 mmol) in toluene (8 mL). Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 32:68] on silica gel (petroleum ether/Et_2O, 70:30) afforded sulfinamide (S_S,*R*)-**2h** (61 mg, 22%) as a white solid, an intermediate fraction containing a mixture of both isomers of **2h** (12 mg, 4%), and sulfinamide (S_S,*S*)-**2h** (135 mg, 48%) as a pale yellow solid. (S_S,*R*)-**2h**: M.p. 45–46 °C. $[\alpha]_D^{20}$ = +45.0 (c = 0.49, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2959, 1263, 1155, 1068 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –73.0 (s, CF_3) ppm. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.26 (s, 9 H), 1.94 (s, 3 H), 3.81 (s, 3 H), 3.92 (s, 1 H), 6.88 (ddd, J = 1.0, 2.0, 8.0 Hz, 1 H), 7.17 (d, J = 8.0 Hz, 1 H), 7.18 (s, 1 H), 7.30 (t, J = 8.0 Hz, 1 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 21.6, 22.6, 55.4, 56.9, 64.0 (q, J = 27.5 Hz), 113.4, 113.9, 118.9, 126.0 (q, J = 285.0 Hz), 129.9, 140.6, 159.8 ppm. HRMS: *m*/*z* calcd. for $C_{14}H_{21}F_3NO_2S$ [M + H]$^+$ 324.1245, found 324.1239. (S_S,*S*)-**2h**: M.p. 62–63 °C. IR (film): $\tilde{\nu}$ = 2959, 1276, 1155 cm^{-1}. $[\alpha]_D^{20}$ = +87.8 (c = 1.03, $CHCl_3$). ^{19}F NMR (235 MHz, $CDCl_3$): δ = –78.4 (s, CF_3) ppm. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.23 (s, 3 H), 1.94 (s, 3 H), 3.75 (s, 1 H), 3.79 (s, 3 H), 6.91 (dd, J = 2.5, 8.0 Hz, 1 H), 7.11 (s, 1 H), 7.13 (d, J = 8.0 Hz, 1 H), 7.30 (t, J = 8.0 Hz, 1 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.6, 23.0, 55.2, 57.0, 63.7 (q, J = 27.5 Hz), 114.0, 115.0, 125.7 (q, J = 285.5 Hz), 129.3, 137.1, 159.4 ppm. HRMS: *m*/*z* calcd. for $C_{14}H_{20}F_3NaNO_2S$ [M + Na]$^+$ 346.1065, found 346.1065.

(+)-(S_S,*S*)-2-Methyl-*N*-[1,1,1-trifluoro-2-(3-methoxyphenyl)pent-4-en-2-yl]propane-2-sulfinamide [(S_S,*S*)-2i]: Following the general procedure A, a solution of allylmagnesium chloride (1.71*M in* THF, 1.16 mL, 1.99 mmol) was added to a solution of hemiaminal **1c** (351 mg, 0.993 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 9:91] on silica gel (petroleum ether/Et_2O, 80:20) afforded a mixture of sulfinamides (S_S,*R*)-**2i** and (S_S,*S*)-**2i** (62 mg, 18%), and sulfinamide (S_S,*S*)-**2i** (163 mg, 47%) as a colorless oil. (S_S,*S*)-**2i**: $[\alpha]_D^{20}$ = +13.4 (c = 1.12, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2960, 1604, 1586, 1257, 1153, 1073 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –73.4 (s, CF_3) ppm. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.24 (s, 9 H), 3.05 (qd, J = 7.0, 14.5 Hz, 2 H), 3.79 (s, 3 H), 4.08 (s, 1 H), 5.18 (d, J = 10.0 Hz, 1 H), 5.25 (dd, J = 1.5, 17.0 Hz, 1 H), 5.60 (m, 1 H), 6.89 (dd, J = 2.0, 8.0 Hz, 1 H), 7.15 (m, 2 H), 7.29 (t, J = 8.0 Hz, 1 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.8, 40.1, 55.3, 57.6, 66.0 (q, J = 26.0 Hz), 114.0, 115.0, 120.4, 121.5, 125.7 (q, J = 287.0 Hz), 129.4, 130.8, 136.5, 159.5 ppm. HRMS: *m*/*z* calcd. for $C_{16}H_{23}F_3NO_2S$ [M + H]$^+$ 350.1402, found 350.1410.

(+)-(S_S,*S*)-2-Methyl-*N*-[1,1,1-trifluoro-2-(3-methoxyphenyl)-4-methylpent-4-en-2-yl]propane-2-sulfinamide [(S_S,*S*)-2j]: Following the general procedure A, a solution of 2-methylallylmagnesium chloride (0.44*M in* THF, 2.49 mL, 1.10 mmol) was added to a solution of hemiaminal **1c** (194 mg, 0.549 mmol) in CH_2Cl_2 (6 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 5:95] on silica gel (petroleum ether/Et_2O, 80:20) afforded a mixture of sulfinamides (S_S,*R*)-**2j** and (S_S,*S*)-**2j** (59 mg, 30%), and sulfinamide (S_S,*S*)-**2j** (*de* = 96%, 68 mg, 34%) as a colorless oil. (S_S,*S*)-**2j**: $[\alpha]_D^{20}$ = +48.8 (*c* = 0.66, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2961, 1647, 1255, 1174 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –72.4 (s, CF_3) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.27 (s, 9 H), 1.45 (s, 3 H), 2.90 (d, *J* = 14.0 Hz, 1 H), 3.02 (d, *J* = 14.0 Hz, 1 H); 3.82 (s, 3 H), 4.26 (s, 3 H), 4.87 (s, 1 H), 4.99 (s, 1 H), 6.90 (dd, *J* = 2.0, 8.0 Hz, 1 H), 7.95 (d, *J* = 8.0 Hz, 1 H), 7.30 (m, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.9, 24.1, 44.1, 55.5, 57.8, 66.4 (q, *J* = 26.0 Hz), 114.2, 115.0, 118.6, 120.6, 125.8 (q, *J* = 287.0 Hz), 129.4, 137.4, 139.2, 159.6 ppm. HRMS: *m*/*z* calcd. for $C_{17}H_{24}F_3NaNO_2S$ $[M + Na]^+$ 386.1378, found 386.1389.

(+)-(S_S,*R*)-2-Methyl-*N*-(1,1,1-trifluoro-2-methylpent-4-en-2-yl)propane-2-sulfinamide [(S_S,*R*)-2k]: Following the general procedure A, a solution of allylmagnesium chloride (1.71*M in* THF, 1.19 mL, 2.03 mmol) was added to a solution of hemiaminal **1d** (265 mg, 1.02 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 15 h. Purification of the residue [**2k** *dr* (S_S,*R*):(S_S,*S*) = 89:11] on silica gel (petroleum ether/Et_2O, 80:20) afforded bis-sulfinamide **3** (10 mg, 5%) as a colorless oil, an intermediate fraction containing sulfinamide (S_S,*R*)-**2k** (78 mg, 30%, *de* = 97%) as a white solid, and a fraction containing a mixture of both isomers of **2k** (30 mg, 12%). (S_S,*R*)-**2k** (*de* = 97%): M.p. 92–93 °C. IR (film): $\tilde{\nu}$ = 2981, 1275, 1185, 1095, 915, 703 cm^{-1}. $[\alpha]_D^{20}$ = +96.0 (*c* = 0.51, $CHCl_3$). ^{19}F NMR (235 MHz, $CDCl_3$): δ = –79.2 (s, CF_3 *minor*), –80.2 (s, CF_3 *major*) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.19 (s, 9 H), 1.54 (s, 3 H), 2.43 (dd, *J* = 8.5, 14.0 Hz, 1 H), 2.55 (dd, *J* = 6.5, 14.0 Hz, 1 H), 3.64 (s, 1 H), 5.23 (d, *J* = 17.0 Hz, 1 H) 5.28 (d, *J* = 9.0 Hz, 1 H), 5.81 (td, *J* = 9.0, 17.0 Hz, 1 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 18.9, 22.6, 41.4, 56.6, 59.7 (q, *J* = 26.5 Hz), 122.0, 126.4 (q, *J* = 284.5 Hz), 130.7 ppm. HRMS: *m*/*z* calcd. for $C_{10}H_{18}F_3NaNOS$ $[M + Na]^+$ 280.0959, found 280.0968.

(+)-(S_S,*S*)-2-Methyl-*N*-(2,2,2-trifluoro-1-phenylethyl)propane-2-sulfinamide [(S_S,*S*)-4a]: Following the general procedure A, a solution of ethylmagnesium bromide (2.99*M in* Et_2O, 572 µL, 1.71 mmol) was added to a solution of hemiaminal **1a** (276 mg, 0.854 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 2:98] on silica gel (petroleum ether/Et_2O, 75:25) afforded sulfinamide (S_S,*S*)-**4a** (142 mg, 60%, *de* = 96%) as a colorless oil. $[\alpha]_D^{20}$ = +103.8 (*c* = 0.69, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2960, 1262, 1171, 1124, 1071, 702 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –74.4 (d, *J* = 7.5 Hz, CF_3 *minor*), –74.7 (d, *J* = 7.0 Hz, CF_3 *major*) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.20 (s, 9 H), 3.97 (d, *J* = 3.0 Hz, 1 H), 4.85 (qd, *J* = 4.0, 7.0 Hz, 1 H), 7.39 (m, 5 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.4. 56.4, 60.6 (q, *J* = 30.5 Hz), 124.6 (q, *J* = 281.5 Hz), 128.8, 129.3, 129.8, 131.8 ppm. HRMS: *m*/*z* calcd. for $C_{12}H_{16}F_3NaNOS$ $[M + Na]^+$ 302.0802, found 302.0798.

(+)-(S_S,*S*)-2-Methyl-*N*-[2,2,2-trifluoro-1-(4-fluorophenyl)ethyl]propane-2-sulfinamide [(S_S,*S*)-4b]: Following the general procedure A, a solution of ethylmagnesium bromide (2.99*M in* Et_2O, 347 µL, 1.04 mmol) was added to a solution of hemiaminal **1b** (177 mg, 0.519 mmol) in CH_2Cl_2 (5 mL) and the reaction was stirred 5 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 4:96] on silica gel (petroleum ether/Et_2O, 75:25) afforded a mixture of sulfinamides (S_S,*R*)-**4b** and (S_S,*S*)-**4b** (22 mg, 14%) as a colorless oil, and sulfinamide (S_S,*S*)-**4b** (90 mg, 58%) as a white solid. (S_S,*S*)-**4b**: M.p. 94–96 °C. $[\alpha]_D^{20}$ = +113.0 (*c* = 0.51, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2961, 1515, 1174, 1125, 1068 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –75.0 (d, *J* = 7.0 Hz, 3 F, CF_3), –111.6 (tt, *J* = 5.5, 8.5 Hz, 1 F, CF) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.21 (s, 9 H), 3.95 (d, *J* = 1.5 Hz, 1 H), 4.88 (qd, *J* = 3.5, 7.5 Hz), 7.10 (t, *J* = 8.5 Hz, 2 H), 7.43 (dd, *J* = 5.5, 8.5 Hz, 2 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.4, 56.4, 59.8 (q, *J* = 30.5 Hz), 116.0 (d, *J* = 22.0 Hz), 124.5 (q, *J* = 281.5 Hz), 127.5, 131.3 (d, *J* = 8.5 Hz), 163.6 (d, *J* = 249.5 Hz) ppm. HRMS: *m*/*z* calcd. for $C_{12}H_{15}F_4NaNOS$ $[M + Na]^+$ 320.0708, found 320.0706.

(+)-(S_S,*S*)-2-Methyl-*N*-[2,2,2-trifluoro-1-(3-methoxyphenyl)ethyl]propane-2-sulfinamide [(S_S,*S*)-4c]: Following the general procedure A, a solution of ethylmagnesium bromide (2.99*M in* Et_2O, 871 µL, 1.74 mmol) was added to a solution of hemiaminal **1c** (308 mg, 0.871 mmol) in CH_2Cl_2 (8 mL) and the reaction was stirred 4 h. Purification of the residue [*dr* (S_S,*R*):(S_S,*S*) = 2:98] on silica gel (petroleum ether/Et_2O, 75:25) afforded sulfinamide (S_S,*S*)-**4c** (196 mg, 73%, *de* = 96%) as a colorless oil. $[\alpha]_D^{20}$ = +91.4 (*c* = 0.99, $CHCl_3$). IR (film): $\tilde{\nu}$ = 2960, 1605, 1458, 1261, 1172, 1124, 1070 cm^{-1}. ^{19}F NMR (235 MHz, $CDCl_3$): δ = –74.3 (d, *J* = 7.5 Hz, CF_3 *minor*), –74.6 (d, *J* = 7.0 Hz, CF_3 *major*) ppm. ^1H NMR (500 MHz, $CDCl_3$): δ = 1.20 (s, 9 H), 3.77 (s, 3 H), 4.01 (d, *J* = 3.5 Hz, 1 H), 4.81 (qd, *J* = 4.0, 7.0 Hz, 1 H), 6.92 (m, 1 H), 6.96 (s, 1 H), 6.98 (d, *J* = 7.5 Hz, 1 H), 7.28 (t, *J* = 8.0 Hz, 1 H) ppm. ^{13}C NMR (125.8 MHz, $CDCl_3$): δ = 22.4, 55.2, 56.5, 60.5 (q, *J* = 30.5 Hz), 115.0, 115.1, 121.6, 124.5 (q, *J* = 281.5 Hz), 129.8, 133.2, 159.8 ppm. HRMS: *m*/*z* calcd. for $C_{13}H_{18}F_3NaNO_2S$ $[M + Na]^+$ 332.0908, found 332.0915.

Supporting Information (see footnote on the first page of this article): Description of general procedure for the cleavage of the *N*-*tert*-butanesulfinyl group and configuration assignment of (S_S,*R*)-**2a**, (S_S,*S*)-**2a** and (S_S,*S*)-**4a**, copies of ^{19}F, ^1H and ^{13}C NMR spectra (sulfinamides **2a–k**, **3** and **4a**–**c**) and X-ray structural data of product **3**.

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[18] The supplementary crystallographic data for the structure of **3** has been deposited with the Cambridge Crystallographic Data Centre as CCDC-942783. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

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