The Preparation of Aliphatic Fluorinated Sulfoximines

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Abstract: This work describes the preparation of an aliphatic series of the *N*-trifluoromethanesulfonyl-*S*-trifluoromethyl-*S*-sulfoximine group. The key step of the synthesis is the imination of fluorinated sulfoxides under experimental conditions, which avoid cleavage of the alkyl group. The formation of sulfoximines **6** and **15** allows the preparation of various fluorinated sulfoximines having strong electron withdrawing properties.

Keywords: fluorine, sulfur, arylations, sulfoximines, imination of sulfoxides

Since their discovery in 1950 by Bentley and Whitehead,[1] sulfoximines have been widely studied. Two main reasons can explain the increasing popularity of this function: the unusual chemical versatility of sulfoximines which have made them widely used in synthesis[2] and the great interest of the potential anti-cancer agent, the methionine sulfoximine (MSO).[3] More recently, easy preparations of optically active forms of sulfoximines have made them very efficient chiral ligands in asymmetric catalysis.[4] Despite the interest in sulfoximines, only a few methods for their synthesis are at the disposal of the organic chemist.

Yagupol'skii et al. in 1986, published the preparation of highly fluorinated sulfoximines, *N*-trifluoromethanesulfonyl-*S*-trifluoromethyl-*S*-arylsulfoximines **1a**–**c**[5] (Figure 1). To the best of our knowledge, the synthesis of this type of sulfoximines has been described only in the aromatic series. By chemical analogy, the skeleton of these compounds is close to the structure of triflones, where one of the oxygens is replaced by the N–SO_2CF_3 group. These particular fluorinated sulfoximines are reported to possess electron-withdrawing effects greater than that of the corresponding triflones.[6]

We describe here the extension of the range of known perfluoroalkylated sulfoximines in the aliphatic series (Figure 1, compounds **2**). Preparation of aliphatic compounds substituted by this powerful electron withdrawing group would be useful for the study of the stabilization of an adjacent carbanion and for the synthesis of highly activated dienophiles.

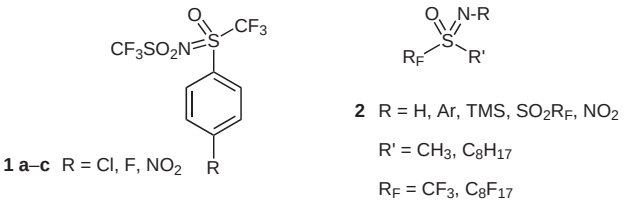

Figure 1

Our synthetic plan was close to the one reported by Yagulpol'skii et al.[5] in the aromatic series but experimental conditions had to be adapted, especially the imination step, in order to be compatible with an aliphatic chain (Scheme 1).

Octyl trifluoromethylsulfide (**4**) was obtained from octanethiol (**3**) and bromotrifluoromethane in the presence of Rongalite® (sodium hydroxymethanesulfinate) and sodium phosphate according to our previously described method.[7] Derivative **4** was not isolated (it was obtained as an inseparable mixture with the dioctyl disulfide) and the crude residue was directly oxidized with MCPBA to give rise to the sulfoxide **5** with an acceptable overall yield from the thiol **3** (28% for the two steps). Subsequent imination of the sulfoxide **5** was crucial and required careful examination of the experimental conditions. The most widely used preparation for the construction of 'free sulfoximines' remains the original hydrazoic acid method developed by Whitehead and Bentley,[8] where sulfuric acid is added to a suspension of sodium azide in chloroform containing the precursor sulfoxide. It has been suggested that the reaction involves nucleophilic attack by the sulfur atom on a protonated hydrazoic acid intermediate.[9] Unfortunately, these conditions are not suited to trifluoromethylsulfoxides, which are not iminated by sodium azide in sulfuric acid.[10] Yagupol'skii et al.[11] have found that imination of aryltrifluoromethylsulfoxides occurs if the sulfuric acid is replaced by oleum and the reaction heated at 70 °C. This last method however seemed to us to be too drastic for our substrate **5**. Under the strongly acidic conditions of this reaction, heterolysis of the carbon–sulfur bond can occur, alkyl groups tend to be lost when a positive charge is built up on sulfur by protonation in the reaction medium.[9] We thus decided to combine the two described methods.[12] Treatment of a suspension of sulfoxide **5** and sodium azide by oleum in dichloromethane at room temperature gave rise to the desired sulfoximine **6** in good yield. Lastly, the latter was transformed into its derivative **7** by treatment with pyridine and trifluoromethanesulfonic anhydride.[13] This reaction sequence allowed us to introduce the *N*-trifluoromethanesulfonyl-*S*-trifluoromethyl-sulfoximine on an alkyl chain with an acceptable 18% overall yield, starting from the commercial thiol.

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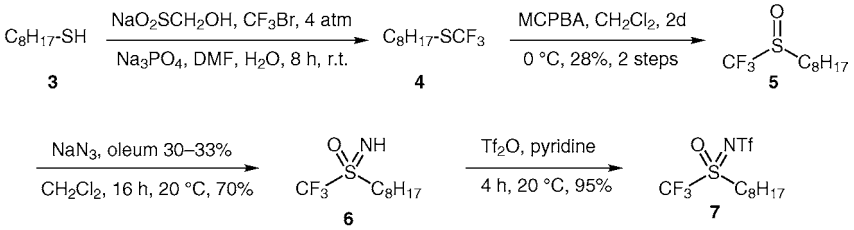
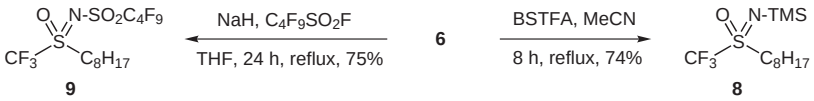


Scheme 1



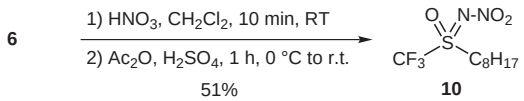
Scheme 2

The relatively easy preparation of the versatile 'free sulfoximine' **6** allowed us to develop the synthesis of various fluorinated sulfoximines possessing electron withdrawing properties.

Compound **6** was thus converted into its trimethylsilyl derivative **8** by treatment with bis(trimethylsilyl)trifluoroacetamide (BSTFA), in good yield. Utilization of bis(trimethylsilyl)acetamide (BSA)[14] gave a much lower yield. Sulfoximine **8** is also a convenient intermediate for the preparation of other funtionalized sulfoximines. Furthermore, treatment of **6** with base and perfluorobutanesulfonyl fluoride gave rise to the sulfoximine **9** in a good yield (Scheme 2).

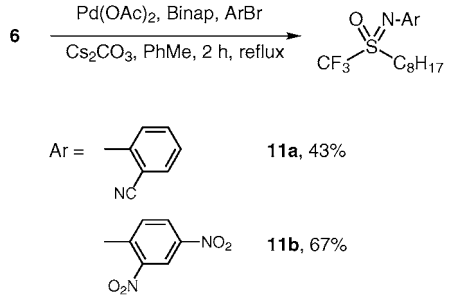
Another means to increase the electron withdrawing power of our sulfoximine was to introduce a nitro group on the nitrogen. For this purpose, we used a method already described for non-fluorinated sulfoximines.[15] Treatment of the sulfoxide **6**, first with nitric acid to protonate **6**, then with acetic anhydride (Scheme 3) and catalytic sulfuric acid gave rise to the compound **10**.

Bolm et al.[16] have published an efficient method to introduce aromatic rings on to the nitrogen of sulfoximines. The authors described the *N*-arylation of non-fluorinated



Scheme 3

sulfoximines by coupling with various aryl bromides, in the presence of palladium acetate and BINAP as an electron rich ligand. To our delight, this procedure was efficiently applied to our sulfoximines. Under the described conditions, benzonitrile and 2,4-dinitrobenzene were introduced on the nitrogen of the sulfoximine **6** to afford respectively **11a** and **11b** in reasonable yield (Scheme 4).

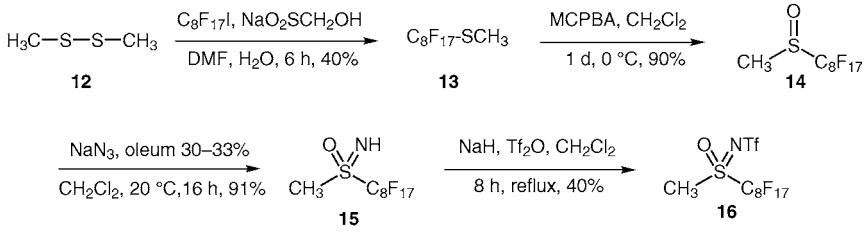


Scheme 4

The methodology described in Scheme 1 has also been applied to the synthesis of the new sulfoximine **16** as presented in Scheme 5. Dimethyl disulfide was perfluorooctylated following our method[17] and the resulting thioether was oxidized with MCPBA to give rise to the sulfoxide **14**. Imination was then carried out in good yield. However, introduction of the triflyl group proved difficult due to the low solubility of the free sulfoximine **15**. Sulfoximine **16** was thus obtained in four steps starting from the commercial dimethyl disulfide **12**.

In conclusion, we have described an efficient methodology suitable for the synthesis of new fluorinated sulfoximines, with high electron withdrawing power, in the aliphatic series. Further applications of these new compounds in organic chemistry are currently under investigation in our laboratory.

Melting points were determined on a Mettler FP61 apparatus. NMR spectra were recorded in $CDCl_3$ solutions, on a Bruker AC-300 spectrometer. Reported coupling constants and chemicals shifts were based on a first-order analysis. Internal reference was the residual peak of $CHCl_3$ (7.27 ppm) for ^1H (300 MHz) NMR spectra, central peak of $CDCl_3$ (77 ppm) for ^{13}C (75 MHz) NMR spectra, internal $CFCl_3$ (0 ppm) for ^{19}F (282 MHz) NMR spectra. Chemical shifts are reported in parts per million (ppm) and constants *J* in Hertz (Hz). The peaks are characterized by s (singlet), d (doublet), t (triplet). Mass spectra were carried out at the Ecole Normale



Scheme 5

Supérieure (Paris). IR spectra were recorded on a Nicolet 400SD spectrometer. Elemental analyses were determined by the Microanalytical laboratory of the CNRS (Gif sur Yvette). Column chromatography was performed with Merck silica gel (70–230 mesh) using various solvents. Reagents were obtained from various commercial sources and used as received. All solvents were distilled prior to use and all reactions were carried out under argon.

Octyl Trifluoromethylsulfoxide (5)

A mixture of octanethiol (20 g, 0.14 mol) and sodium phosphate (27 g, 0.16 mol) in DMF (270 mL) was stirred for 15 min in a heavy walled glass flask (Parr apparatus). H_2O (13 mL) and Rongalite (63.3 g, 0.41 mol) were then quickly introduced. The flask was immediately evacuated (5 mm Hg) before being connected to a bromotrifluoromethane pressure cylinder. The pressure was maintained at 4.5 bar, with constant shaking, during the absorption process which takes ca. 8 h. The apparatus was vented, then the supernatant liquor was removed and diluted with H_2O (500 mL). The remaining salts were taken up in Et_2O (100 mL), filtered on celite, and washed with Et_2O (100 mL). The aq phase was extracted with Et_2O (5 × 300 mL). The combined organic layers were washed with $NaHCO_3$ (5 × 300 mL), brine, then dried over $MgSO_4$ and concentrated under reduced pressure. The crude mixture was diluted in CH_2Cl_2 (680 mL), then MCPBA 70% (84.3 g, 0.48 mol) was added at 0 °C. The reaction was stirred for 2 d at this temperature, then filtered on celite. The organic layer was washed with H_2O (2 × 200 mL), $NaHCO_3$ (5 × 300 mL), brine (200 mL), dried over $MgSO_4$, concentrated under reduced pressure and the residue was purified by column chromatography (pentane–Et_2O, 98:2). Compound **5** was isolated as a colorless oil in 28% (8.9 g) yield.

IR (neat): 2962, 2930, 2853, 1205 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 3.08 (m, 1 H, C*H*$_1$H$_2$S), 2.87 (m, 1 H, CH$_1$*H*$_2$S), 1.90 (m, 2 H, CH_2), 1.51 (m, 2 H, CH_2), 1.32 (m, 8 H, 4 CH_2), 0.88 (t, 3 H, *J* = 8.1 Hz, CH_3).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 125.3 (q, CF_3, *J* = 340.2 Hz), 48.4 (q, CH_2S, *J* = 2.8 Hz), 31.5, 28.9, 28.8, 28.5, 22.4, 21.6, 13.9 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –74.3 (s, CF_3).

MS (EI, 70 eV): *m*/*z* (%) = 161 (5) [M – CF_3], 112 (20), 83 (75), 69 (100).

Anal. Calcd for $C_9H_{17}F_3OS$: C, 46.94; H, 7.44. Found: C, 47.19; H, 7.66.

***S*-Trifluoromethyl-*S*-octyl-sulfoximine (6)**

A mixture of sulfoxide **5** (5 g, 21.7 mmol) and NaN_3 (2.8 g, 43.5 mmol) in CH_2Cl_2 (31 mL) was cooled to 0 °C. Oleum 30–33% (10 mL) was added dropwise at this temperature, then the reaction was stirred for 16 h at r.t. under a slight pressure of argon and then poured onto ice. The phases were separated and the aq phase was extracted with CH_2Cl_2 (3 × 50 mL). The organic layers were mixed, dried over $MgSO_4$ and concentrated under reduced pressure. Purification by distillation under vacuum (90 °C, 1 mm Hg) afforded the desired sulfoximine **6** as a colorless liquid in 70% (3.8 g) yield.

IR (neat): 3149 (br), 2960, 2929, 2847, 1193 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 3.17 (m, 2 H, CH_2S), 1.95 (m, 2 H, CH_2), 1.47 (m, 2 H, CH_2), 1.27 (m, 8 H, 4 CH_2), 0.88 (t, 3 H, *J* = 8.1 Hz, CH_3).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 120.7 (q, CF_3, *J* = 340.8 Hz), 49.1 (CH_2S), 31.6, 28.9, 28.8, 28.4, 22.4, 20.7, 13.8 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –79.7 (s, CF_3).

MS (CI, NH_3): *m*/*z* = 246 [MH^+].

HRMS: *m*/*z* calcd for $C_9H_{19}F_3ONS$: 246.1139; found, 246.1145.

Anal. Calcd for $C_9H_{18}F_3NOS$: C, 44.07; H, 7.40; N, 5.71. Found: C, 44.03; H, 7.38; N, 5.83.

***S*-Perfluorooctyl-*S*-methyl-sulfoximine (15)**

White powder; yield: 91% (2.83 g).

Mp 123.8 °C

IR (nujol): 3144 (br), 2955, 2924, 2852, 1465, 1260, 1198 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 3.16 (s, 3 H).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 37.6 (CH_3).

^{19}F NMR (282 MHz, CD_3OD): δ = –81.2 (s, CF_3), –111.9 (d, AB system, SC*F*$_1$F$_2$), –117.1 (d, AB system, SCF$_1$*F*$_2$), –120.5 (d, CF_2), –121.9 (s, 3 CF_2), –123.1 (s, CF_2), –126.6 (s, CF_2).

MS (CI, NH_3): *m*/*z* = 515 [M + 18].

HRMS: *m*/*z* calcd for $C_9H_4F_{17}NOS$: 497.9820; found, 497.9821.

***N*-Trifluoromethanesulfonyl-*S*-trifluoromethyl-*S*-octyl-sulfoximine (7)**

A mixture of the sulfoximine **6** (0.3 g, 1.22 mmol) and pyridine (0.3 g, 3.66 mmol) in CH_2Cl_2 (14 mL) was cooled to 0 °C. Triflic anhydride (0.5 g, 1.83 mmol) was added dropwise at this temperature, then the reaction was stirred for 4 h at r.t. CH_2Cl_2 (30 mL) was added and the organic layer was washed with H_2O (30 mL), HCl 2 N (3 × 20 mL), H_2O (20 mL), dried over $MgSO_4$, concentrated under reduced pressure and the residue was purified by column chromatography (pentane–Et_2O, 9:1). Compound **7** was isolated as a colorless oil in 95% (0.44 g) yield.

IR (neat): 2965, 2924, 2858, 1465, 1383, 1234 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 3.59 (m, 2 H, CH_2S), 2.03 (m, 2 H, CH_2), 1.54 (m, 2 H, CH_2), 1.32 (m, 8 H, 4 CH_2), 0.89 (t, 3 H, *J* = 8.1 Hz, CH_3).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 119.9 (q, CF_3, *J* = 331.3 Hz), 118.9 (q, CF_3, *J* = 320.5 Hz), 52.0 (CH_2S), 31.5, 28.7, 28.6, 27.8, 22.4, 20.7, 13.8 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –73.7 (s, CF_3), –78.8 (s, CF_3).

MS (CI, NH_3): *m*/*z* = 395 [M + 18].

MS (EI, 70 eV): *m*/*z* (%) = 377 (2%), [M^+], 196 (40), 69 (100).

HRMS: *m*/*z* calcd for $C_{10}H_{17}F_6NO_3S_2$: 378.0632; found, 378.0636.

Anal. Calcd for $C_{10}H_{18}F_6NO_3S_2$: C, 31.83; H, 4.54; N, 3.71. Found: C, 32.17; H, 4.61; N, 3.74.

***N*-Trimethylsilyl-*S*-trifluoromethyl-*S*-octyl-sulfoximine (8)**

A soln of the sulfoximine **6** (0.5 g, 2.04 mmol) and bis(trimethylsilyl)trifluoroacetamide BSTFA (0.68 g, 2.65 mmol) in CH_3CN (5 mL) was refluxed for 8 h. The reaction mixture was concentrated under reduced pressure and the residue was purified by column chromatography (pentane–Et_2O, 9:1). Compound **8** was isolated as a colorless oil in 74% (0.5 g) yield.

IR (neat): 2960, 2924, 2858, 1475, 1280, 1183 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 3.04 (m, 2 H, CH_2S), 1.84 (m, 2 H, CH_2), 1.43 (m, 2 H, CH_2), 1.29 (m, 8 H, 4 CH_2), 0.89 (t, 3 H, *J* = 8.1 Hz, CH_3), 0.20 (s, 9 H, $SiMe_3$).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 120.5 (q, CF_3, *J* = 341.3 Hz), 52.6 (CH_2S), 31.6, 28.9, 28.8, 28.3, 22.5, 20.7, 13.9 (CH_3), 1.6 (s, $SiMe_3$).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –80.2 (s, CF_3).

MS (CI, NH_3): *m*/*z* = 246 [(M – $SiMe_3$) + 1].

HRMS: *m*/*z* calcd for $C_{12}H_{27}F_3NOSSi$: 318.1535; found, 318.1528.

***N*-Perfluorobutylsulfonyl-*S*-trifluoromethyl-*S*-octyl-sulfoximine (9)**

A soln of the sulfoximine **6** (1.8 g, 7.34 mmol) in THF (35 mL) was cooled to 0 °C. NaH 60% in mineral oil (0.6 g, 14.7 mmol) was added portionwise under argon and the reaction stirred for 2 h at r.t. Perfluorobutanesulfonyl fluoride (6.73 g, 22.1 mmol) was added and the reaction was stirred for 6 h at r.t. and 16 h at reflux. The reaction mixture was poured into H_2O (40 mL). The aq layer was extracted with CH_2Cl_2 (3 × 50 mL), dried over $MgSO_4$, concentrated under reduced pressure and the residue was purified by column chromatography (pentane–Et_2O, 9:1). Compound **9** was isolated as a colorless oil in a 75% (2.9 g) yield.

IR (neat): 2960, 2934, 2857, 1475, 1388, 1234, 1183 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 3.62 (m, 2 H, CH_2S), 2.08 (m, 2 H, CH_2), 1.55 (m, 2 H, CH_2), 1.37 (m, 8 H, 4 CH_2), 0.90 (t, 3 H, *J* = 8.1 Hz, CH_3).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 52.2 (CH_2S), 31.4, 28.5, 28.4, 27.7, 22.3, 20.8, 13.5 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –73.9 (s, CF_3), –81.3 (s, CF_3), –112.3 (s, CF_2), –121.5 (s, CF_2), –126.5 (s, CF_2).

MS (CI, NH_3): *m*/*z* = 545 [M + 18].

HRMS: *m*/*z* calcd for $C_{13}H_{18}F_{12}NO_3S_2$: 528.0537; found, 528.0532.

Anal. Calcd for $C_{13}H_{17}F_{12}NO_3S_2$: C, 29.61; H, 3.25; N, 2.66. Found: C, 29.57; H, 3.27; N, 2.76.

***N*-Nitro-*S*-trifluoromethyl-*S*-octyl-sulfoximine (10)**

HNO_3 100% (0.088 mL) was added dropwise to a soln of the sulfoximine **6** (0.5 g, 2.04 mmol) in CH_2Cl_2 (4 mL). The reaction mixture was stirred for 10 min and cooled to 0 °C. Acetic anhydride (4 mL), H_2SO_4 (1 drop) were added and the reaction mixture was stirred for 15 min at 0 °C, then for 1 h at ambient temperature. $CH_2Cl_2$was added and the organic phase was washed with H_2O (10 mL), $NaHCO_3$ (3 × 30 mL), H_2O (20 mL), dried over $MgSO_4$, concentrated under reduced pressure and the residue purified by column chromatography (pentane–Et_2O, 95:5). Compound **10** was isolated as a colorless oil in 51% (0.31 g) yield.

IR (neat): 2955, 2919, 2852, 2253, 1541, 1465, 1301, 1260, 1132 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 3.47 (m, 2 H, CH_2S), 2.01 (m, 2 H, CH_2), 1.51 (m, 2 H, CH_2), 1.32 (m, 8 H, 4 CH_2), 0.89 (t, 3 H, *J* = 8.1 Hz, CH_3).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 120.9 (q, CF_3, *J* = 341.9 Hz), 48.3 (CH_2S), 31.5, 28.7, 28.6, 28.1, 22.4, 21.6, 13.9 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –66.3 (s, CF_3).

MS (CI, NH_3): *m*/*z* = 291 [MH^+], 308 [M + 18].

HRMS: *m*/*z* calcd for $C_9H_{18}F_3N_2O_3S$: 291.0990; found, 291.0988.

Anal. Calcd for $C_9H_{17}F_3N_2O_3S$: C, 37.24; H, 5.90; N, 9.65. Found: C, 37.45; H, 5.92; N, 9.54.

***N*-(2-Cyanophenyl)-*S*-trifluoromethyl-*S*-octyl-sulfoximine (11a)**

A soln of the sulfoximine **6** (0.16 g, 0.65 mmol) in toluene (6.5 mL) was transferred via canula to a Schlenk tube charged with $Pd(OAc)_2$ (0.0073 g, 0.0325 mmol) and BINAP (0.0305 mg, 0.049 mmol). 2-bromobenzonitrile (0.12 g, 0.65 mmol) and cesium carbonate (0.3 g, 0.91 mmol) were added, the reaction was heated at reflux for 2 h then concentrated under reduced pressure. The residue was purified by column chromatography (pentane–Et_2O, 9:1). Compound **11a** was isolated as a colorless oil in 43% (0.12 g) yield.

IR (neat): 2960, 2924, 2858, 2228, 1598, 1480, 1449, 1332, 1198 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 7.57 (dd, 1 H, CH_6Ar, $J_{H6–H5}$ = 7.9 Hz, $J_{H6–H4}$ = 1.6 Hz), 7.44 (ddd, 1 H, CH_5Ar, $J_{H5–H4}$ = 8.2 Hz, $J_{H5–H3}$ = 1.6 Hz), 7.34 (dd, 1 H, CH_3Ar, $J_{H3–H4}$ = 7.5 Hz), 7.11 (ddd, 1 H, CH_4Ar), 3.47 (m, 1 H, CH_1H_2S), 3.34 (m, 1 H, CH_1H_2S), 2.10 (m, 2 H, CH_2), 1.54 (m, 2 H, CH_2), 1.30 (m, 8 H, 4 CH_2), 0.89 (t, 3 H, *J* = 8.1 Hz, CH_3).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 145.1 (C–N), 133.4 (CH), 133.3 (CH), 123.6 (CH), 123.2 (CH), 121.2 (q, CF_3, *J* = 340.2 Hz), 117.2 (C–CN), 108.7 (CN), 51.2 (CH_2S), 31.6, 28.8, 28.7, 28.2, 22.5, 21.0, 13.9 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –73.0 (s, CF_3).

MS (CI, NH_3): *m*/*z* = 364 [M + 18].

HRMS: *m*/*z* calcd for $C_{16}H_{22}F_3N_2OS$: 347.1405; found, 347.1404.

Anal. Calcd for $C_{16}H_{21}F_3N_2OS$: C, 55.48; H, 6.11; N, 8.09. Found: C, 55.86; H, 6.25; N, 7.84.

***N*-(2,4-Dinitrophenyl)-*S*-trifluoromethyl-*S*-octyl-sulfoximine (11b)**

Colorless oil; yield: 67% (0.22 g).

IR (neat): 2955, 2934, 2858, 1608, 1536, 1480, 1342, 1198 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 8.62 (d, 1 H, CH_3Ar, $J_{H3–H5}$ = 2.6 Hz), 8.28 (dd, 1 H, CH_5Ar, $J_{H5–H6}$ = 8.9 Hz), 7.59 (d, 1 H, CH_6Ar), 3.42 (m, 2 H, CH_2S), 2.05 (m, 2 H, CH_2), 1.53 (m, 2 H, CH_2), 1.30 (m, 8 H, 4 CH_2), 0.89 (t, 3 H, *J* = 8.1 Hz, CH_3).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 144.2 (C–N), 142.3 (C–NO_2), 142.0 (C–NO_2), 127.2 (CH), 124.9 (CH), 121.0 (q, CF_3, *J* = 345.0 Hz), 120.6 (CH), 51.4 (CH_2S), 31.5, 28.8, 28.7, 28.0, 22.5, 20.7, 13.9 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): – 73.3 (s, CF_3).

MS (CI, NH_3): *m*/*z* = 429 [M + 18].

HRMS: *m*/*z* calcd for $C_{15}H_{21}F_3N_3O_5S$: 412.1154; found, 412.1149.

Anal. Calcd for $C_{15}H_{20}F_3N_2O_5S$: C, 43.79; H, 4.90; N, 10.21. Found: C, 44.03; H, 5.09; N, 10.51.

Perfluorooctyl Methylsulfide (13)

Dimethyl disulfide (5 g, 53 mmol) was dissolved in DMF (65 mL) under argon. Perfluorooctyl iodide $C_8F_{17}I$ (60.82 g, 111.4 mmol), pre-washed with a 10% aq soln of $Na_2S_2O_5$, was added followed by H_2O (4 mL). Lastly, sodium hydroxymethanesulfinate (24.5 g, 159.2 mmol) was added in portions over 6 h. The soln was stirred

at r.t. for 20 h and diluted with H_2O (300 mL). The mixture was extracted with Et_2O (3 × 100 mL) and the organic layer washed with $NaHCO_3$ (5% in H_2O, 3 × 100 mL) and H_2O (200 mL), then dried over $MgSO_4$, and concentrated under reduced pressure. Purification by distillation under vacuum (60 °C, 15 mm Hg) afforded the desired sulfide **13** as a colorless liquid in 40% (20 g) yield.

^{1}H NMR (300 MHz, $CDCl_3$): δ = 2.41 (s, 3 H).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 40.2 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –81.6 (s, CF_3), –91.2 (s, CF_2), –120.6 (CF_2), –122.0 (s, CF_2), –122.6 (s, 2 CF_2), –123.5 (s, CF_2), –126.9 (s, CF_2).

Perfluorooctyl Methylsulfoxide (14)

Compound **13** (6.00 g, 12.8 mmol) was diluted in CH_2Cl_2 (65 mL) and mCPBA 70% (3.17 g, 12.8 mmol) was added at 0 °C. The reaction was stirred for 1 d at this temperature, then filtered over celite. The organic layer was washed with H_2O (2 × 200 mL), $NaHCO_3$ (5 × 300 mL), brine (200 mL), dried over $MgSO_4$ then concentrated under reduced pressure. Compound **14** was isolated without further purification as a white powder in 90% (5.60 g) yield; mp 85.2 °C.

IR (nujol): 2929, 2960, 2858, 1460, 1372 cm^{-1}.

^{1}H NMR (300 MHz, $CDCl_3$): δ = 2.87 (s, 3 H).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 34.1 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –81.1 (s, CF_3), –116.7 (d, AB system, SCF_1F_2), –121.1 (s, CF_2), –122.3 (s, 3 CF_2), –123.2 (s, CF_2), –124.1 (d, AB system, SCF_1F_2), –126.6 (s, CF_2).

MS (CI, NH_3): *m*/*z* = 500 [M + 18].

HRMS: *m*/*z* calcd for $C_9H_3F_{17}OS$: 482.9711; found, 482.9716.

***N*-Trifluoromethanesulfonyl-*S*-perfluorooctyl-*S*-methyl-sulfoximine (16)**

To a soln of the sulfoximine **15** (0.75 g, 1.52 mmol) in CH_2Cl_2 (15 mL), NaH 60% dispersion in mineral oil (0.1 g, 2.43 mmol) was added in portions at 0 °C. The reaction mixture was refluxed for 30 min and cooled again to 0 °C. Triflic anhydride (0.86 g, 3.03 mmol) was then added dropwise, then the reaction mixture was refluxed for 8 h and poured into ice. The phases were separated and the aq phase was extracted with CH_2Cl_2 (3 × 50 mL). The organic layers were combined, dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by column chromatography (pentane–Et_2O, 9:1). Compound **16** was isolated as colorless oil in a 40% (0.54 g) yield.

Mp 127 °C.

IR (nujol): 2950, 2924, 2847, 1470, 1383, 1219, 1152 cm^{-1}.

^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.69 (s, 3 H).

^{13}C NMR (77 MHz, $CDCl_3$): δ = 40.1 (CH_3).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –78.9 (s, NSO_2CF_3), –81.2 (s, CF_3), –108.2 (d, AB system, SCF_1F_2), –111.3 (d, AB system, SCF_1F_2), –119.1 (d, CF_2), –121.6 (s, CF_2), –122.0 (s, CF_2), –122.3 (s, CF_2), –123.1 (s, CF_2), –126.5 (s, CF_2).

MS (CI, NH_3): *m*/*z* = 647 [M + 18].

HRMS: *m*/*z* calcd for $C_{10}H_3F_{20}NO_3S_2$: 629.9313; found, 629.9307.

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