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Mild electrophilic trifluoromethylthiolation of ketones with trifluoromethanesulfanamide†

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Wei Wu, Xuxue Zhang, Fang Liang and Song Cao*

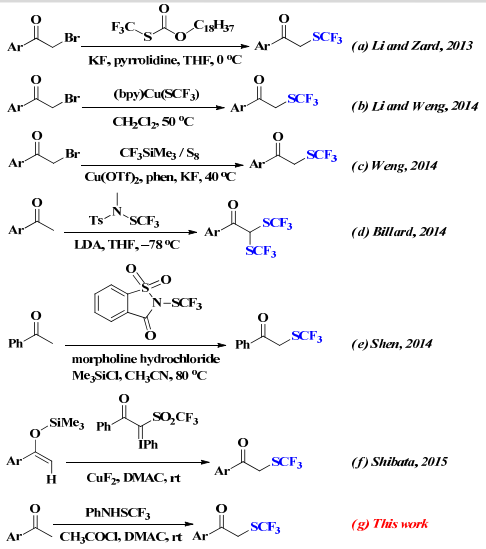
A straightforward and convenient approach for trifluoromethylthiolation of various acyclic and cyclic ketones with $PhNHSCF_3$ was described. The reaction proceeds smoothly in the presence of acetyl chloride at room temperature and affords α-trifluoromethylthiolated ketones in fair to good yields.

Introduction

Trifluoromethylthiolated organic compounds have found many applications in the fields of pharmaceuticals, agrochemicals, and advanced materials due to their unique lipophilicity and bioactivities.[1] Furthermore, the introduction of the trifluoromethylthio group (−CF_3S) into small molecules is an important transformation in organic synthesis.[2] Therefore, the development of efficient approaches for the selective introduction of a CF_3S group into organic compounds has attracted increasing attention from synthetic chemists.[3] Up to now, a variety of methods and many useful trifluoromethylthiolating reagents have been developed for the trifluoromethylthiolation of various organic molecules[4] such as the copper-mediated trifluoromethylthiolation of aryl boronic acids with $[NMe_4][SCF_3]$ and air,[5] the Pd-catalyzed synthesis of aryl trifluoromethylsulfides by the reaction of aryl bromides with $AgSCF_3$,[6] the silver-mediated radical aryltrifluoromethylthiolation of activated alkenes.[7]

Recently, α-trifluoromethylthiolated carbonyl compounds have gained growing interest due to their special properties imparted by the trifluoromethylthio group.[8] However, most of the researches focused on the selective introduction of the CF_3S group into the α-position of β-ketoesters or esters with different trifluoromethylthiolated reagents,[9] the α-trifluoromethylthiolation of simple ketones still remains important synthetic challenges.[10]

Of the current methods for the synthesis of CF_3S-substituted ketones, the reactions of α-bromoketones with different trifluoromethylthiolating reagents (Scheme 1a, b and c) are very efficient and useful.[11] The drawback of these methods is that the prefunctionalization of ketone with halogen such as aromatic α-bromoketones were generally required. In 2014, Billard developed a general method to synthesize a large variety of α-trifluoromethylthiolated carbonyl compounds by using *N*-methyl-*N*-tosyltrifluoromethanesulfanamide.[12] However, when primary aromatic ketones or silylenol ethers were used as substrates, bistrifluoromethylthiolated products were formed. Furthermore, the reaction should be performed at very low temperature (–78 ℃) (Scheme 1d). Shen described the electrophilic trifluoromethylthiolation of acetophenone with *N*-trifluoromethylthiosaccharin to afford the corresponding α-monotrifluoromethylthiolated carbonyl compound (Scheme 1e).[13] Most recently, Shibata reported the reaction of silylenol ethers with trifluoromethanesulfonyl hypervalent iodoniumylide in the presence of a catalytic amount of CuF_2 to give the α-CF_3S-substituted ketones (Scheme 1f).[14]



Scheme 1 Methods for synthesis of α-CF_3S-substituted ketones

The stable trifluoromethanesulfanamide ($PhNHSCF_3$) can be used as an electrophilic source for the trifluoromethylthio group.[15] This trifluoromethylthiolation reagent exhibited good reactivity for the functionalization of 2-alkynylaniline,[16] 1-methoxy-2-alkynylbenzenes,[17] allylsilanes,[18] alkenes.[19] However, methods for the direct trifluoromethylthiolation of sp^3 C−H bonds with

Shanghai Key Laboratory of Chemical Biology, School of Pharmacy, East ChinaUniversity of Science and Technology (ECUST), Shanghai 200237, China
**Corresponding author. Tel: +86-21-64253452; fax: +86-21-64252603, E-mail address: scao@ecust.edu.cn*

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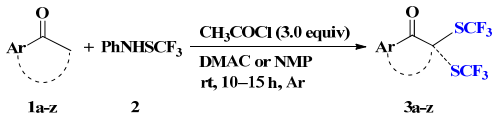
$PhNHSCF_3$ are still limited. In this paper, we report a direct and practical protocol for trifluoromethylthiolation of a variety of ketones using $PhNHSCF_3$ as trifluoromethylthiolating reagent in the presence of acetyl chloride at room temperature (Scheme 2).

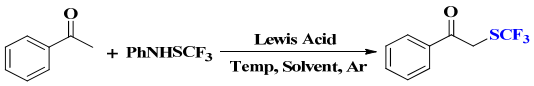


Scheme 2 Trifluoromethylthiolation of various ketones

Results and discussion

The initial studies were carried out by using the reaction of acetophenone **1a** and $PhNHSCF_3$ **2** as the model reaction to optimize the reaction conditions (Table 1). We first investigated the influence of Lewis acid on the reaction. Among the tested Lewis acids (entries 1−5), the best activity was observed with CH_3COCl, affording **3a** in 88% yield (entry 5). The effects of different solvents were also evaluated (entries 5−11). Gratifyingly, the use of *N*,*N*-dimethylacetamide (DMAC) or 1-methylpyrrolidin-2-one (NMP) as a solvent could significantly improve the yield of the trifluoromethylthiolated product **3a** (entries 5 and 6). The amount of $PhNHSCF_3$ and CH_3COCl exerted an important influence on the yields of trifluoromethylthiolated products. Increasing or decreasing the amount of them led to a decrease in yield (entries 12−16).

Table 1 Optimization of the Reaction Conditions[a]

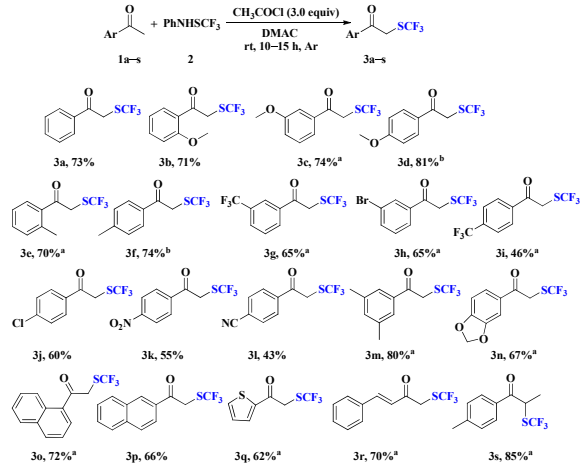


Entry	**2** (eq.)	Lewis acid (eq.)	Solvent	Temp (^oC)	Yield of **3a** (%)[b]
1	2.5	$BiCl_3$(3.0)	NMP	100	0
2	2.5	TsCl(3.0)	NMP	rt	65
3	2.5	$ClCH_2COCl$(3.0)	NMP	rt	56
4	2.5	ClCOCOCl(3.0)	NMP	rt	63
5	2.5	CH_3COCl(3.0)	NMP	rt	88
6	2.5	CH_3COCl(3.0)	DMAC	rt	85
7	2.5	CH_3COCl(3.0)	DMSO	rt	0
8	2.5	CH_3COCl(3.0)	toluene	rt	0
9	2.5	CH_3COCl(3.0)	CH_2Cl_2	rt	7
10	2.5	CH_3COCl(3.0)	DMF	rt	70
11	2.5	CH_3COCl(3.0)	THF	rt	75
12	1.5	CH_3COCl(3.0)	DMAC	rt	54
13	2.0	CH_3COCl(3.0)	DMAC	rt	63
14	3.0	CH_3COCl(3.0)	DMAC	rt	78
15	2.5	CH_3COCl(2.5)	DMAC	rt	60
16	2.5	CH_3COCl(3.5)	DMAC	rt	65
17	2.5	CH_3COCl(3.0)	DMAC	0	23
18	2.5	CH_3COCl(3.0)	DMAC	80	48

[a] Reagents and conditions: **1a** (0.25 mmol), solvent (3 mL), 10−15 h. [b] Yields obtained by GC analysis and based on **1a**.

Finally, reactions performed either at elevated temperature (80 °C) or lower temperatures (0 °C) would result in lower yields (entries 17 and 18).

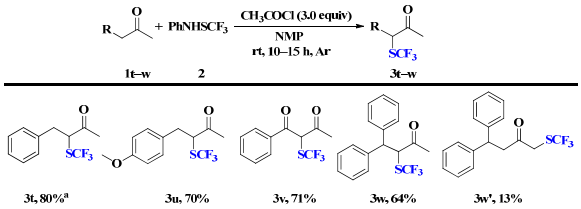
With the optimal reaction conditions in hand (Table1, entry 5), the scope of this CH_3COCl-promoted trifluoromethylthiolation of different ketone derivatives was investigated (Scheme 3). In general, the reaction tolerated a variety of ketone substrates with both electron-donating and electron-withdrawing substituents to afford the corresponding trifluoromethylthiolated products in moderate to good yields. To our delight, only a trace amount of the bistrifluoromethylthiolated products could be observed. The ketone substrates bearing electron-donating groups such as Me and MeO had a beneficial effect on the reactivity and afforded the desired products in good yields, especially in the case of *p*-MeO-substituted substrate **2d**, which was converted to the trifluoromethylthiolation product **3d** in 81% yield. The ketones containing electron-withdrawing groups gave slightly lower yields than those bearing electron-donating groups (**2i**, **2k**, **2l** *vs* **2c**, **2d**, **2f**). 1-(Naphthalen-1-yl)ethanone (**2o**) and 1-(naphthalen-2-yl)ethanone (**2p**) were also suitable substrates and provided the desired product **3o** and **3p** in 72% and 66% yields, respetively. Replacing the aryl group by the thienyl group in ketone also afforded trifluoromethylthiolated product **3q** in a moderate yield. We were pleased to find that (*E*)-4-phenylbut-3-en-2-one (**2r**) and 1-(*p*-tolyl)propan-1-one (**2s**) were compatible with the reaction and the products (**3r** and **3s**) were isolated in good yields.



Scheme 3 Scope of trifluoromethylthiolation of various ketones. Reagents and conditions: **1a**–**s** (0.25 mmol), **2** (0.625 mmol), CH_3COCl (0.75 mmol), DMAC (3 mL), rt, Ar. Isolated yields. [a] NMP (3 mL). [b] 100 °C.

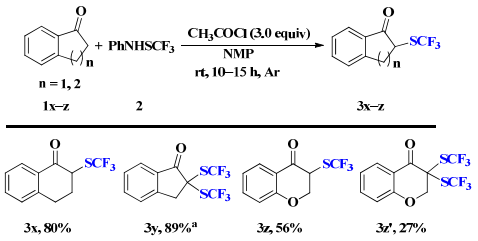
Encouraged by the results obtained with the ketones, we next employed this C−H α-trifluoromethylthiolation protocol to other dialkylsubstituted ketones which contain both primary and secondary α-hydrogen atoms (Scheme 4). Much to our delight, the reaction proceeded smoothly with high regioselectivity and the secondary α-C−H bond trifluoromethylthiolation products were isolated as the sole products (**3t**, **3u** and **3v**). In the case of 4,4-diphenylbutan-2-one, the secondary C−H trifluoromethylthiolation product (**3w**) was obtained only in a moderate yield of 64% along with 13% of the primary C−H trifluoromethylthiolation product

(**3w′**). The relatively low regioselectivity might be ascribed to the steric hindrance of two benzene rings. This reaction is the first example of the regioselectivity for secondary C−H bond trifluoromethylthiolation of dialkylsubstituted ketones.



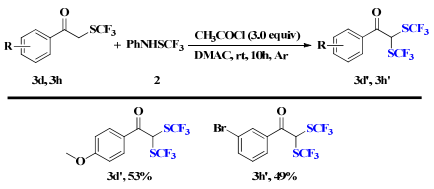
Scheme 4 Trifluoromethylthiolation of dialkylsubstituted ketones. Reagents and conditions: **1t**–**w** (0.25 mmol), **2** (0.625 mmol), CH_3COCl (0.75 mmol), NMP (3 mL), rt, Ar. Isolated yields. [a] 5 h.

The scope of this reaction was further demonstrated in the trifluoromethylthiolation of the cyclic ketones (Scheme 5). It was found that the cyclic six-membered ring ketone could provide the α-monotrifluoromethylthiolated product in good yield (**3x**), whereas the cyclic five-membered ring ketone could afford the bistrifluoromethylthiolated product in high yield (**3y**). It should be noted that only **3x** or **3y** were observed even when the amount of $PhNHSCF_3$ increased to 3.0 equiv. or decreasing to 1.5 equiv., respectively. When chroman-4-one was used as substrate, a mixture of monotrifluoromethylthiolated product (**3z**) and *bis*-trifluoromethylthiolated product (**3z′**) was obtained, which was easily separated by column chromatography.



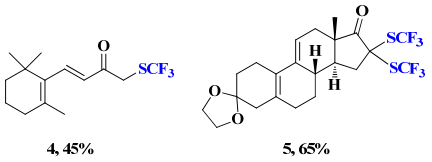
Scheme 5 Trifluoromethylthiolation of cyclic ketones. Reagents and conditions: **1x**–**z** (0.25 mmol), **2** (0.625 mmol), CH_3COCl (0.75 mmol), NMP (3 mL), rt, Ar. Isolated yields. [a] 5 h.

Interestingly, the monotrifluoromethylthiolated products (**3d**, **3h**) could be further trifluoromethylthiolated by $PhNHSCF_3$ and bistrifluoromethylated products (**3d′**, **3h′**) were obtained in moderate yields (Scheme 6).



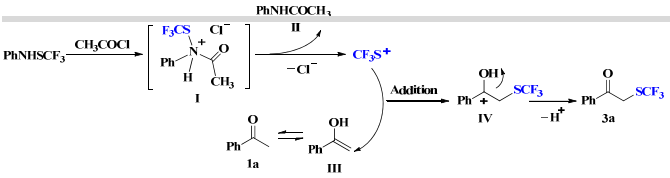
Scheme 6 Trifluoromethylthiolation of monotrifluoromethylthiolated products. Reagents and conditions: **3d**, **3h** (0.25 mmol), **2** (0.625 mmol), CH_3COCl (0.75 mmol), DMAC (3 mL), rt, Ar. Isolated yields.

Finally, this electrophilic trifluoromethylthiolation was also applied to two commercially available natural products, beta-Jonone and Estradiene dione-3-keta, and mono- and bis-CF_3S products were obtained in moderate yields, respectively (Scheme 7, **4** and **5**).



Scheme 7 Trifluoromethylthiolation of beta-Jonone and Estradiene dione-3-keta.

On the basis of the previous literatures[17-19], a plausible reaction mechanism was proposed (Scheme 8, with **1a** as the example). Firstly, $PhNHSCF_3$ was activated by Lewis acid, acetyl chloride, to form the highly reactive electrophilic species **I**. The key intermediate trifluoro-methanesulfanyl cation CF_3S^+ was yielded by the release of chloride and *N*-phenylacetamide **II** which could be detected by GC-MS. Subsequently, the addition of CF_3S^+ to the enolate of **1a** (**III**) would furnish the intermediate **IV**. Loss of a proton from **IV** resulted in the generation of the desired trifluoromethylthiolated product.



Scheme 8 Plausible reaction mechanism

Conclusions

In summary, we have developed a general and facile approach for trifluoromethylthiolation of various acyclic and cyclic ketones using $PhNHSCF_3$ as an electrophilic CF_3S source with the assistance of acetyl chloride. Compared with previous methods, this novel protocol for the installation of the trifluoromethylthio group into ketone compounds has several notable features, such as mild reaction conditions, high regioselectivity, the avoidance of prefunctionalization of starting materials, and inexpensive and readily available trifluoromethylthiolating reagent. Therefore, we anticipate the present methodology will be a powerful alternative approach for the synthesis of α-trifluoromethylthiolated ketones.

Experimental section

General information

All reagents were of analytical grade, and obtained from commercial suppliers and used without further purification. All reactions were carried out under argon with dry solvents under anhydrous conditions. DMAC and NMP were freshly dried and stored over activated 4Å molecular sieves under argon. The products were purified by column chromatography over silica gel (300–400 mesh size). Melting points were measured in an open capillary using Büchi melting point B-540 apparatus and are uncorrected. ^{1}H NMR

and ^{13}C NMR spectra were recorded on a Bruker AM-400 spectrometer (400 MHz and 100 MHz, respectively) using TMS as internal standard. The ^{19}F NMR were obtained using a Bruker AM-400 spectrometer (376 MHz) with $CDCl_3$ as the NMR solvent. Gas chromatography-mass spectra (GC-MS) were recorded on HP 5973 MSD with 6890 GC. High resolution mass spectra (HRMS) were recorded under electron impact conditions using a MicroMass GCT CA 055 instrument and recorded on a MicroMass LCTTM spectrometer. Trifluoromethanesulfanylamide **2** was prepared on multi-grams scale according to the literature procedure.[15a]

General procedure of synthesis

General procedure for the synthesis of compounds **3a-z**: To a mixture of ketones **1** (0.25 mmol) and $PhNHSCF_3$ **2** (120.6 mg, 0.625 mmol) in dry DMAC or NMP (2 mL) was slowly added a solution of CH_3COCl (58.9 mg, 0.75 mmol) in DMAC or NMP (1 mL) by syringe at room temperature under argon atmosphere. After stirring at room temperature for 10–15 hours (monitored by TLC), the mixture was quenched by water (10 mL) and extracted with EtOAc (10 mL × 3). The combined organic layer was washed with water (10 mL), saturated NH_4Cl solution (10 mL), dried over Na_2SO_4, and concentrated in vacuo. The residue was then purified by chromatography using EtOAc/*n*-hexane (1/20) as eluent to provide the corresponding products **3a-z**.

Synthesis of compounds **3d′** and **3h′**: To a mixture of CH_3COCl (58.9 mg, 0.75 mmol) and $PhNHSCF_3$ **2** (120.6 mg, 0.625 mmol) in dry DMAC (2 mL) was slowly added a solution of **3d** or **3h** (0.25 mmol) in DMAC (1 mL) by syringe at room temperature under argon atmosphere. After stirring at room temperature for 13 hours (monitored by TLC), the mixture was quenched by water (10 mL) and extracted with EtOAc (10 mL × 3). The combined organic layer was washed with water (10 mL), saturated NH_4Cl solution (10 mL), dried over Na_2SO_4, and concentrated in vacuo. The residue was then purified by chromatography on silica gel using EtOAc/*n*-hexane (1/20) as eluent to provide the corresponding products **3d′**, **3h′**.

Synthesis of compound **4**: To a mixture of beta-Jonone (48.0 mg, 0.25 mmol) and $PhNHSCF_3$ **2** (96.5 mg, 0.5 mmol) in dry NMP (1.5 mL) was slowly added a solution of CH_3COCl (58.9 mg, 0.75 mmol) in NMP (1 mL) by syringe at room temperature under argon atmosphere. After stirring at room temperature for 15 hours (monitored by TLC), the mixture was quenched by water (10 mL) and extracted with EtOAc (10 mL × 3). The combined organic layer was washed with water (10 mL), saturated NH_4Cl solution (10 mL), dried over Na_2SO_4, and concentrated in vacuo. The residue was then purified by chromatography on silica gel using EtOAc/*n*-hexane (1/20) as eluent to provide the corresponding product **4**.

Synthesis of compound **5**: To a mixture of Estradiene dione-3-keta (78.5 mg, 0.25 mmol), $PhNHSCF_3$ **2** (144.8 mg, 0.75 mmol) in dry NMP (1.5 mL) was slowly added a solution of CH_3COCl (98.1 mg, 1.25 mmol) in NMP (1 mL) by syringe at room temperature under argon atmosphere. After stirring at room temperature for 15 hours (monitored by TLC), the mixture was quenched by water (10 mL) and extracted with EtOAc (10 mL × 3). The combined organic layer was washed with water (10 mL), saturated NH_4Cl solution (10 mL), dried over Na_2SO_4, and concentrated in vacuo. The residue was then purified by chromatography on silica gel using EtOAc/*n*-hexane (1/20) as eluent to provide the corresponding product **5**.

Phenyl-2-((trifluoromethyl)thio)ethanone (3a). Compound **3a** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 15 h using DMAC as the solvent. light yellow oil; yield: 73%; ^1H NMR (400 MHz, $CDCl_3$) δ 7.96–7.94 (m, 2H), 7.66–7.62 (m, 1H), 7.53–7.49 (m, 2H), 4.52 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.0, 134.7, 134.3, 130.7 (q, $^1J_{CF}$ = 304.5 Hz), 129.0, 128.4, 38.4 (d, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F).

1-(2-Methoxyphenyl)-2-((trifluoromethyl)thio)ethanone (3b). Compound **3b** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using DMAC as the solvent. yellow solid; mp: 67.1–68.0 °C; yield: 71%; ^1H NMR (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 7.8, 1.8 Hz, 1H), 7.57–7.53 (m, 1H), 7.07–6.99 (m, 2H), 4.43 (s, 2H), 3.95 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.3, 159.0, 135.2, 131.4, 130.9 (q, $^1J_{CF}$ = 304.4 Hz), 124.8, 121.2, 111.6, 55.7, 42.5 (d, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.6 (s, 3F).

1-(3-Methoxyphenyl)-2-((trifluoromethyl)thio)ethanone (3c). Compound **3c** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using NMP as the solvent. yellow oil; yield: 74%; ^1H NMR (400 MHz, $CDCl_3$) δ 7.52–7.46 (m, 2H), 7.43–7.39 (m, 1H), 7.19–7.16 (m, 1H), 4.49 (s, 2H), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.9, 160.1, 136.0, 130.7 (q, $^1J_{CF}$ = 304.6 Hz), 130.0, 121.0, 120.7, 112.7, 55.5, 38.4 (d, $^3J_{CF}$ = 1.7 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F).

1-(4-Methoxyphenyl)-2-((trifluoromethyl)thio)ethanone (3d). Compound **3d** was prepared according to the general procedure. The reaction mixture was stirred at 100 °C for 14 h using DMAC as the solvent. yellow oil; yield: 81%; ^1H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 8.8 Hz, 2H), 4.47 (s, 2H), 3.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.4, 163.4, 129.8 (q, $^1J_{CF}$ = 304.4 Hz), 129.8, 126.7, 113.1, 54.6, 37.2 (d, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.5 (s, 3F).

1-(*o*-Tolyl)-2-((trifluoromethyl)thio)ethanone (3e). Compound **3e** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 12 h using NMP as the solvent. light yellow solid; mp: 27.4–28.1 °C; yield: 70%; ^1H NMR (400 MHz, $CDCl_3$) δ 7.68–7.66 (m, 1H), 7.47–7.43 (m, 1H), 7.33–7.29 (m, 2H), 4.45 (s, 2H), 2.54 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.8, 139.8, 134.7, 132.7, 132.6, 130.7 (q, $^1J_{CF}$ = 304.6 Hz), 129.1, 126.0, 40.4 (d, $^3J_{CF}$ = 1.8 Hz), 21.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F); HRMS (EI): calcd. for $C_{10}H_9F_3OS$ $[M]^+$: 234.0326, found: 234.0327.

1-(*p*-Tolyl)-2-((trifluoromethyl)thio)ethanone (3f). Compound **3f** was prepared according to the general procedure. The reaction mixture was stirred at 100 °C for 12 h using DMAC as the solvent. yellow solid; mp: 65.2–67.8 °C; yield: 74%; ^1H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.4 Hz, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 4.47 (s,

2H), 3.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.6, 145.4, 132.2, 130.8 (q, $^1J_{CF}$ = 304.4 Hz), 129.6, 128.5, 38.4 (d, $^3J_{CF}$ = 1.7 Hz), 21.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.5 (s, 3F).

1-(3-(Trifluoromethyl)phenyl)-2-((trifluoromethyl)thio)ethanone (3g). Compound **3g** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 15 h using NMP as the solvent. light yellow oil; yield: 65%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20–7.89 (m, 3H), 7.60–7.67 (m, 1H), 4.53 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.9, 135.2, 131.7 (q, $^2J_{CF}$ = 33.1 Hz), 131.5, 130.5 (q, $^1J_{CF}$ = 304.7 Hz), 130.6 (q, $^3J_{CF}$ = 3.5 Hz), 129.7, 125.2 (q, $^3J_{CF}$ = 3.8 Hz), 123.4 (q, $^1J_{CF}$ = 270.9 Hz), 38.1 (q, $^3J_{CF}$ = 2.0 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.5 (s, 3F), –63.0 (s, 3F); HRMS (EI): calcd. for $C_{10}H_6F_6OS$ $[M]^+$: 288.0044, found: 288.0043.

1-(3-Bromophenyl)-2-((trifluoromethyl)thio)ethanone (3h). Compound **3h** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using NMP as the solvent. light yellow oil; yield: 65%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06–8.05 (m, 1H), 7.88–7.86 (m, 1H), 7.76–7.74 (m, 1H), 7.41–7.37 (m, 1H), 4.48 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.8, 137.1, 136.3, 131.4, 130.5, 130.5 (q, $^1J_{CF}$ = 304.8 Hz), 126.9, 123.3, 38.2 (d, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F); HRMS (EI): calcd. for $C_9H_6BrF_3OS$ $[M]^+$: 299.9254, found: 299.9251.

1-(4-(Trifluoromethyl)phenyl)-2-((trifluoromethyl)thio)ethanone (3i). Compound **3i** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 15 h using NMP as the solvent. light yellow solid; mp: 57.7–59.1 °C; yield: 46%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, J = 8.0 Hz, 2H), 7.79 (d, J = 8.4 Hz, 2H), 4.51 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.2, 137.3, 135.5 (q, $^2J_{CF}$ = 32.7 Hz), 130.4 (q, $^1J_{CF}$ = 304.8 Hz), 128.8, 126.1 (q, $^3J_{CF}$ = 3.7 Hz), 123.3 (q, $^1J_{CF}$ = 271.2 Hz), 38.1 (q, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.5 (s, 3F), –63.3 (s, 3F); HRMS (EI): calcd. for $C_{10}H_6F_6OS$ $[M]^+$: 288.0044, found: 288.0043.

1-(4-Chlorophenyl)-2-((trifluoromethyl)thio)ethanone (3j). Compound **3j** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using DMAC as the solvent. yellow solid; mp: 59.0–61.5 °C; yield: 60%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, J = 8.8 Hz, 2H), 7.49 (d, J = 8.8 Hz, 2H), 4.47 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.9, 140.9, 133.0, 130.6 (q, $^1J_{CF}$ = 304.7 Hz), 129.8, 129.0, 38.1 (d, $^3J_{CF}$ = 1.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F); HRMS (EI): calcd. for $C_9H_6ClF_3OS$ $[M]^+$: 253.9780, found: 253.9778.

1-(4-Nitrophenyl)-2-((trifluoromethyl)thio)ethanone (3k). Compound **3k** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using DMAC as the solvent. yellow solid; mp: 81.7–83.4 °C; yield: 55%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, J = 8.8 Hz, 2H), 8.15 (d, J = 8.8 Hz, 2H), 4.54 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.8, 150.9, 139.0, 130.3 (q, $^1J_{CF}$ = 305 Hz), 129.6, 124.2, 38.2 (d, $^3J_{CF}$ = 1.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F).

4-(2-((Trifluoromethyl)thio)acetyl)benzonitrile (3l). Compound **3l** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using DMAC as the solvent. yellow solid; mp: 72.5–74.0 °C; yield: 43%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (d, J = 8.8 Hz, 2H), 7.83 (d, J = 8.8 Hz, 2H), 4.49 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.9, 137.6, 132.8, 130.3 (q, $^1J_{CF}$ = 305 Hz), 128.9, 117.5, 38.0 (d, $^3J_{CF}$ = 1.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F).

1-(3,5-Dimethylphenyl)-2-((trifluoromethyl)thio)ethanone (3m). Compound **3m** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 15 h using NMP as the solvent. white solid; mp: 63.6–65.9 °C; yield: 80%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (s, 2H), 7.26 (s, 1H), 4.49 (s, 2H), 2.38 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.3, 138.7, 135.9, 134.8, 130.8 (q, $^1J_{CF}$ = 304.4 Hz), 126.2, 38.6 (d, $^3J_{CF}$ = 1.8 Hz), 21.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.4 (s, 3F); HRMS (EI): calcd. for $C_{11}H_{11}F_3OS$ $[M]^+$: 248.0483, found: 248.0497.

1-(Benzo[d][1,3]dioxol-5-yl)-2-((trifluoromethyl)thio)ethanone (3n). Compound **3n** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 15 h using NMP as the solvent. yellow solid; mp: 89.8–91.2 °C; yield: 67%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55–7.52 (m, 1H), 7.40–7.39 (m, 1H), 6.89–6.87 (m, 1H), 6.07 (s, 2H), 4.45 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 190.0, 152.8, 148.6, 130.7 (q, $^1J_{CF}$ = 304.5 Hz), 129.4, 125.1, 108.1, 107.9, 102.2, 38.2 (q, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.5 (s, 3F); HRMS (EI): calcd. for $C_{10}H_7F_3O_3S$ $[M]^+$: 264.0068, found: 264.0069.

1-(Naphthalen-1-yl)-2-((trifluoromethyl)thio)ethanone (3o). Compound **3o** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 10 h using NMP as the solvent. brown solid; mp: 58.4–60.9 °C; yield: 72%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69–8.67 (m, 1H), 8.04–8.02 (m, 1H), 7.88–7.86 (m, 2H), 7.63–7.59 (m, 1H), 7.56–7.52 (m, 1H), 7.50–7.46 (m, 1H), 4.56 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.0, 134.4, 134.1, 132.5, 130.8 (q, $^1J_{CF}$ = 304.7 Hz), 130.3, 128.9, 128.8, 128.6, 126.9, 125.6, 124.2, 40.6 (q, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.3 (s, 3F); HRMS (EI): calcd. for $C_{13}H_9F_3OS$ $[M]^+$: 270.0326, found: 270.0327.

1-(Naphthalen-2-yl)-2-((trifluoromethyl)thio)ethanone (3p). Compound **3p** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 14 h using DMAC as the solvent. yellow solid; mp: 75.1–78.2 °C; yield: 66%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (s, 1H), 7.95–7.91 (m, 2H), 7.87–7.84 (m, 2H), 7.63–7.53 (m, 2H), 4.60 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.9, 136.0, 132.4, 132.0, 130.8 (q, $^1J_{CF}$ = 304.6 Hz), 130.5, 129.7, 129.2, 128.9, 127.9, 127.2, 123.5, 38.5 (d, $^3J_{CF}$ = 1.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.3 (s, 3F).

1-(Tthiophen-2-yl)-2-((trifluoromethyl)thio)ethanone (3q). Compound **3q** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using NMP as the solvent. yellow solid; mp: 48.7–50.1 °C; yield: 62%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (dd, J = 3.8, 1.0 Hz, 1H), 7.75 (dd, J = 5.0, 1.0 Hz, 1H), 7.19 (dd, J = 5.0, 3.8 Hz, 1H), 4.44 (s, 2H); ^{13}C

NMR (100 MHz, $CDCl_3$) δ 184.8, 141.3, 135.4, 133.3, 130.5 (q, $^1J_{CF}$ = 304.8 Hz), 128.5, 37.6 (q, $^3J_{CF}$ = 2.0 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.5 (s, 3F); HRMS (EI): calcd. for $C_7H_5F_3OS_2$ $[M]^+$: 225.9734, found: 225.9735.

(*E*)-4-Phenyl-1-((trifluoromethyl)thio)but-3-en-2-one (3r). Compound **3r** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 12 h using NMP as the solvent. yellow solid; mp: 41.3–43.6 °C; yield: 70%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 16.0 Hz, 1H), 7.58–7.56 (m, 2H), 7.46–7.39 (m, 3H), 6.87 (d, *J* = 16.0 Hz, 1H), 4.10 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.6, 145.3, 133.8, 131.3, 130.6, (q, $^1J_{CF}$ = 304.8 Hz), 129.1, 128.7, 122.9, 39.3 (d, $^3J_{CF}$ = 1.7 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.5 (s, 3F); HRMS (EI): calcd. for $C_{11}H_9F_3OS$ $[M]^+$: 248.0483, found: 248.0486.

1-(*p*-Tolyl)-2-((trifluoromethyl)thio)propan-1-one (3s). Compound **3s** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 12 h using NMP as the solvent. yellow oil; yield: 85%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 4.97 (q, *J* = 7.2 Hz, 1H), 2.43 (s, 3H), 1.71 (d, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.0, 145.3, 131.4, 132.3 (q, $^1J_{CF}$ = 305.1 Hz), 129.7, 128.9, 44.6 (q, $^3J_{CF}$ = 44.6 Hz), 21.7, 19.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ –39.8 (s, 3F); HRMS (EI): calcd. for $C_{11}H_{11}F_3OS$ $[M]^+$: 248.0483, found:248.0484.

4-Phenyl-3-((trifluoromethyl)thio)butan-2-one (3t). Compound **3t** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 5 h using NMP as the solvent. light yellow oil; yield: 80%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33–7.23 (m, 3H), 7.18–7.16 (m, 2H), 4.03 (dd, *J* = 8.8, 6.4 Hz, 1H), 3.25 (dd, *J* = 14.0, 8.8 Hz, 1H), 3.07 (dd, *J* = 14.0, 6.4 Hz, 1H), 2.17 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 203.6, 136.5, 130.2 (q, $^1J_{CF}$ = 305.7 Hz), 129.1, 128.8, 127.4, 53.9 (d, $^3J_{CF}$ = 0.5 Hz), 37.6, 28.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ –39.9 (s, 3F); HRMS (EI): calcd. for $C_{11}H_{11}F_3OS$ $[M]^+$: 248.0483, found: 248.0486.

4-(4-Methoxyphenyl)-3-((trifluoromethyl)thio)butan-2-one (3u). Compound **3u** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 12 h using NMP as the solvent. yellow oil; yield: 70%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.10 (d, *J* = 8.4 Hz, 2H), 6.84 (d, *J* = 8.4 Hz, 2H), 3.99 (dd, *J* = 8.8, 6.4 Hz, 1H), 3.79 (s, 3H), 3.19 (dd, *J* = 14.0, 9.2 Hz, 1H), 3.03 (dd, *J* = 8.8, 6.4 Hz, 1H), 2.18 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 204.0, 158.8, 130.2 (q, $^1J_{CF}$ = 305.6 Hz), 130.2, 128.3, 114.2, 55.2, 54.0, 36.8, 28.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ –39.9 (s, 3F); HRMS (EI): calcd. for $C_{12}H_{13}F_3O_2S$ $[M]^+$: 278.0588, found: 278.0587.

1-Phenyl-2-((trifluoromethyl)thio)butane-1,3-dione (3v). Compound **3v** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 11 h using NMP as the solvent. yellow oil; yield: 71%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63–7.61 (m, 2H), 7.53–7.48 (m, 1H), 7.46–7.42 (m, 2H), 2.58 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 201.7, 195.0, 135.6, 131.3, 129.1 (q, $^1J_{CF}$ = 309.1 Hz), 128.7, 127.9, 95.3 (d, $^3J_{CF}$ = 1.7 Hz), 25.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ –40.1 (s, 3F, ketone), –45.9 (s, 3F, enol); HRMS (EI): calcd. for $C_{11}H_9F_3O_2S$ $[M]^+$: 262.0275, found: 262.0273.

4,4-Diphenyl-3-((trifluoromethyl)thio)butan-2-one (3w); 4,4-diphenyl-1-((trifluoromethyl)thio)butane-2-one (3w′). Compound **3w** and **3w′** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 15 h using NMP as the solvent. Compound **3w**: yellow oil; yield: 64%; Compound **3w′**: yellow oil; yield: 13%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33–7.32 (m, 4H, **3w** and **3w′**), 7.30–7.17 (m, 16H, **3w** and **3w′**), 4.66 (d, *J* = 12.4 Hz, 1H, **3w**), 4.59 (t, *J* = 7.6 Hz, 1H, **3w′**), 4.25 (d, *J* = 12.4 Hz, 1H, **3w**), 3.60 (s, 2H, **3w′**), 3.32 (d, *J* = 7.6 Hz, 2H, **3w′**), 2.09 (s, 3H, **3w**); ^{13}C NMR (100 MHz, $CDCl_3$) δ 203.8 (**3w**), 201.2 (**3w′**), 143.1 (**3w′**), 140.0 (**3w**), 139.6 (**3w**), 130.3 (q, $^1J_{CF}$ = 304.9 Hz, **3w′**), 129.9 (q, $^1J_{CF}$ = 306.0 Hz, **3w**), 129.1 (**3w**), 128.9 (**3w**), 128.8 (**3w′**), 128.1 (**3w**), 127.8 (**3w**), 127.7 (**3w**), 127.6 (**3w**), 127.6 (**3w′**), 126.8 (**3w′**), 56.4 (**3w**), 52.3 (**3w**), 47.2 (**3w′**), 46.2 (**3w′**), 40.7 (d, $^3J_{CF}$ = 1.7 Hz, **3w′**), 27.7 (**3w**); ^{19}F NMR (376 MHz, $CDCl_3$) δ –39.7 (s, 3F, **3w**), –41.7 (s, 3F, **3w′**); HRMS (EI): calcd. for $C_{17}H_{15}F_3OS$ $[M]^+$: 324.0796, found: 324.0795.

2-((Trifluoromethyl)thio)-3,4-dihydronaphthalen-1(2*H*)-one (3x). Compound **3x** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 13 h using NMP as the solvent. yellow oil; yield: 80%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04–8.02 (m, 1H), 7.55–7.51 (m, 1H), 7.36–7.33 (m, 1H), 7.28–7.26 (m, 1H), 4.38–4.34 (m, 1H), 3.14–3.11 (m, 2H), 2.73–2.66 (m, 1H), 2.44–2.34 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.2, 143.0, 135.4, 131.1, 130.8 (q, $^1J_{CF}$ = 305.2 Hz), 129.2, 128.8, 128.2, 127.2, 51.8 (d, $^3J_{CF}$ = 0.6 Hz), 31.2, 28.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ –38.7 (s, 3F); HRMS (EI): calcd. for $C_{11}H_9F_3OS$ $[M]^+$: 246.0326, found: 246.0328.

2,2-Bis((trifluoromethyl)thio)-2,3-dihydro-1*H*-inden-1-one (3y). Compound **3y** was prepared according to the general procedure. The reaction mixture was stirred at room temperature for 5 h using NMP as the solvent. yellow oil; yield: 89%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90–7.88 (m, 1H), 7.78–7.74 (m, 1H), 7.54–7.49 (m, 1H), 3.93 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.1, 148.1, 137.0, 131.3, 129.2, 128.8 (q, $^1J_{CF}$ = 309.4 Hz), 126.2, 126.1, 62.9, 44.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ –37.1 (s, 3F); HRMS (EI): calcd. for $C_{11}H_6F_6OS_2$ $[M]^+$: 331.9764, found: 331.9762.

3-((Trifluoromethyl)thio)chroman-4-one (3z) and **3,3-Bis((trifluoromethyl)thio)chroman-4-one (3z′).** Compound **3z** and **3z′** were prepared according to the general procedure. The reaction mixture was stirred at room temperature for 12 h using NMP as the solvent. The ratio of **3z** and **3z′** is 2:1. Compound **3z**: yellow oil; yield: 56%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92–7.90 (m, 1H), 7.56–7.52 (m, 1H), 7.10–7.07 (m, 1H), 7.02–7.00 (m, 1H), 4.81–4.77 (m, 1H), 4.55–4.50 (m, 1H), 4.45–4.41 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 186.3, 161.0, 136.9, 130.2 (q, $^1J_{CF}$ = 305.7 Hz), 128.0, 122.3, 119.6, 117.9, 70.6, 47.9 (d, $^3J_{CF}$ = 0.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –38.8 (s, 3F); HRMS (EI): calcd. for $C_{10}H_7F_3O_2S$ $[M]^+$: 248.0119, found: 248.0117. Compound **3z′**: yellow oil; yield: 27%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99–7.97 (m, 1H), 7.63–7.59 (m, 1H), 7.19–7.15 (m. 1H), 7.06–7.04 (m, 1H), 4.79 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 182.9, 159.6, 137.4, 129.0, 128.7 (q, $^1J_{CF}$

= 309.2 Hz), 123.2, 117.8, 117.7, 73.4, 64.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ –35.4 (s, 3F); HRMS (EI): calcd. for $C_{11}H_6F_6O_2S_2$ $[M]^+$: 347.9713, found: 347.9711.

1-(4-Methoxyphenyl)-2,2-bis((trifluoromethyl)thio)ethanone (3d′). The reaction mixture was stirred at room temperature for 13 h with DMAC as the solvent. yellow oil; yield: 53%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, J = 8.8 Hz, 2H), 6.99 (d, J = 8.8 Hz, 2H), 6.65 (s, 1H), 3.90 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 186.1, 165.1, 132.2, 129.7 ($^1J_{CF}$ = 307.2 Hz), 124.2, 114.5, 55.7, 49.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ –40.6 (s, 3F); HRMS (EI): calcd. for $C_{11}H_8F_6O_2S_2$ $[M]^+$: 349.9870, found: 349.9871.

1-(3-Bromophenyl)-2,2-bis((trifluoromethyl)thio)ethanone (3h′). The reaction mixture was stirred at room temperature for 13 h using DMAC as the solvent. yellow oil; yield: 49%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15–8.14 (m, 1H), 7.96–7.93 (m, 1H), 7.82–7.79 (m, 1H), 7.45–7.41 (m, 1H), 6.59 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 186.3, 137.9, 133.4, 132.5, 130.6, 129.4 (q, $^1J_{CF}$ = 307.5 Hz), 128.0, 123.5, 61.7 (q, $^3J_{CF}$ = 2.2 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –40.4 (s, 3F); HRMS (EI): calcd. for $C_{10}H_5BrF_6OS_2$ $[M]^+$: 397.8869, found: 397.8871.

(*E*)-1-((trifluoromethyl)thio)-4-(2,6,6-trimethylcyclohex-1-en-1-yl)but-3-en-2-one (4). The reaction mixture was stirred at room temperature for 15 h using NMP as the solvent. yellow oil; yield: 45%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, J = 16.0 Hz, 1H), 6.31 (d, J = 16.4 Hz, 1H), 4.00 (s, 2H), 2.11 (t, J = 6.2 Hz, 2H), 1.81 (s, 3H), 1.66–1.60 (m, 2H), 1.51–1.48 (m, 2H), 1.09 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.9, 145.0, 139.3, 135.9, 130.6 (q, $^1J_{CF}$ = 304.7 Hz), 126.7, 39.8, 39.1 (q, $^3J_{CF}$ = 1.7 Hz), 34.1, 33.9, 28.7, 21.8, 18.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ –41.6 (s, 3F); HRMS (EI): calcd. for $C_{14}H_{19}F_3OS$ $[M]^+$: 292.1109, found: 292.1108.

Cyclic-3-(1,2-ethanediylacetal)-estra-5(10),9(11)-dien-16,16-bis((trifluoromethyl)thio)-3,17-dione (5). The reaction mixture was stirred at room temperature for 15 h using NMP as the solvent. light yellow oil; yield: 65%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.58 (s, 1H), 4.00 (s, 4H), 2.73 (dd, J = 14.4, 4.8 Hz, 1H), 2.54–2.44 (m, 2H), 2.35–2.30 (m, 4H), 2.25–2.10 (m, 4H), 2.05–1.98 (m, 1H), 1.91–1.74 (m, 3H), 1.37 (qd, J = 12.4, 5.2 Hz, 1H), 1.09 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 207.5, 136.8, 131.2, 129.0 (q, $^1J_{CF}$ = 309.1 Hz), 128.4 ($^1J_{CF}$ = 309.6 Hz), 125.9, 116.1, 107.8, 64.5, 64.4, 64.3, 46.6, 44.2, 41.2, 40.1, 36.4, 35.0, 31.2, 30.6, 26.6, 24.6, 17.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ –36.7 (s, 3F), –38.1 (s, 3F); HRMS (EI): calcd. for $C_{22}H_{24}F_6O_3S_2$ $[M]^+$: 514.1071, found: 514.1073.

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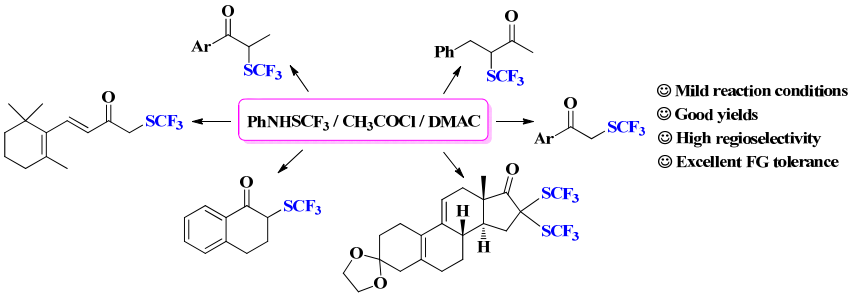
Graphical abstract:

Mild Electrophilic Trifluoromethylthiolation of Ketones with Trifluoromethanesulfanamide

Wei Wu, Xuxue Zhang, Fang Liang, and Song Cao*

Shanghai Key Laboratory of Chemical Biology, School of Pharmacy, East China University of Science and Technology (*ECUST*), Shanghai 200237, China



A straightforward and convenient approach for trifluoromethylthiolation of various acyclic and cyclic ketones with $PhNHSCF_3$ was described. The reaction proceeds smoothly in the presence of acetyl chloride at room temperature and affords α-trifluoromethylthiolated ketones in fair to good yields.