J. prakt. Chem. 339 (1997) 697–707

Journal für praktische Chemie
Chemiker-Zeitung

Originalarbeiten · Full Papers

Synthesis and Reactivity of Trifluorodithioacetates Derived from Trifluorothioacetamides

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Received September 24th, 1997

In memoriam Horst Böhme (1908–1996)

Abstract. A general synthesis of trifluorodithioacetates is described by thiolysis of trifluorothioamidium salts, derived from trifluorothioacetamides. The reactivity of these CF_3 bearing C_2 building blocks has been investigated towards nucleophiles and in cycloaddition reactions. Trifluorodithioacetates react with dienes to give thiopyrans and with diazo compounds to give trifluoromethyl vinyl sulphides *via* thiirane intermediates. With amines, trifluorodithioacetates give rise to trifluorothioacetamides while thiols add by thiophilic attack leading to new trifluoroethane dithioacetal disulphide. Two equivalents of phosphite furnish one equivalent of thiophosphate and one of phosphorylated trifluoroethane.

Trifluorothioacetamides **1** are versatile C_2 reagents which bear the important CF_3 substituent. We have previously reported on their chlorination to form amide chlorides **2** [2] and on their *S*-alkylation to form thioamidium salts **3** [3]. Both these intermediates react with two equivalents of thiols to give trifluorodithioalkyl-ortho-acetamides **4**.

Furthermore, we have found that **2** and **4** undergo "α,α'-amine isomerisation" *via* 1,3 dipoles **5** which can be intercepted by dipolarophiles; **5b** may also be obtained simply by deprotonation of **3**. This 1,3 dipolar cycloaddition allows access to new trifluoromethylated pyrrolidines and pyrrolizidines with high diastereoselectivity [3, 4]. These reactions are summarised in the Scheme 1 which also shows the facile synthesis of trifluorodithioacetates **7** from **2** or **3** in a one-pot reaction first by reaction with a molar amount of thiol followed by thiolysis [4]. Although dithioesters **7** have been obtained before [5], they have not been studied thoroughly [6]. This paper describes the preparation and the reactivity of this interesting and versatile class of compounds.

Synthesis of Trifluorodithioacetates

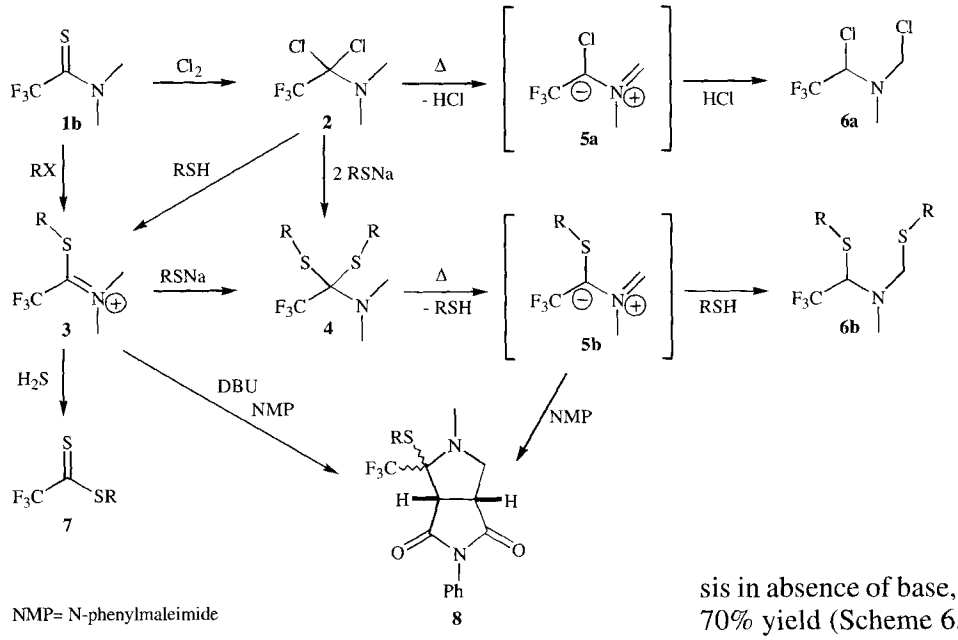
Trifluorothioacetamides are easily prepared by thionation of corresponding amides with P_4S_{10} in excellent yields and on molar scale (Scheme 2 and Tab. 1). Our approach is complementary to the method recently described using Lawesson's reagent [7].

Trifluorothioamidium salts **11** or **12** can be obtained by alkylation of either corresponding thioamides **1** with methyl triflate [3] or *N*,*N*-dimethyl-2,2,2-trifluorothioacetamide **1b** with dimethylsulfate at 85 °C. These salts are not isolated but treated immediately with H_2S. Methyl trifluorodithioacetate **7a** is isolated in 60 to 70% yields (Scheme 3). Monitoring of the thiolysis step by ^{19}F NMR shows this transformation to dithioester **7a** to be quantitative, however the volatility of the product makes its isolation difficult.

Since alkylation of trifluorothioacetamides **1** using more standard alkylating agents is difficult, we have also developed a synthesis of trifluorodithioacetates **7** starting from the amide chloride **13** which is prepared by chlorination [2] of trifluorothioacetamide **1d**. Furthermore, we found that acylation of the *N*-secondary trifluorothioacetamide **1a** gives rise to thioimide **14** which could be isolated by chromatography.

When amide chloride **13** is treated with thiols in chloroform for 1 minute at 0 °C followed by a rapid thioly-

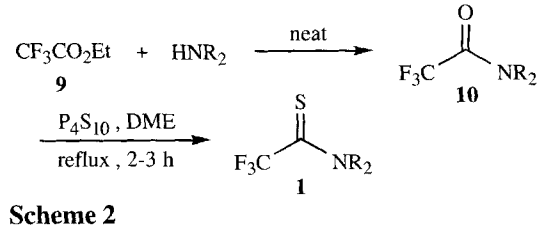
† Deceased 17th of July 1996



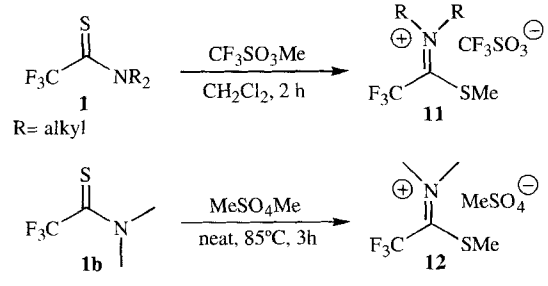
Scheme 1

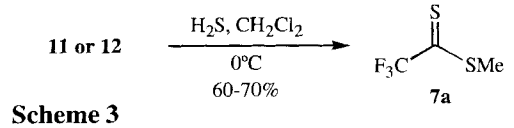
Table 1 Synthesis of amides **10** and thioamides **1**

Entry	Amines HNR_2	Amides **10** %	Thioamides **1** %
a	monomethyl	98	90
b	dimethylamine	91	86
c	pyrrolidine	95	90
d	piperidine	87	93
e	morpholine	92	88



Scheme 2

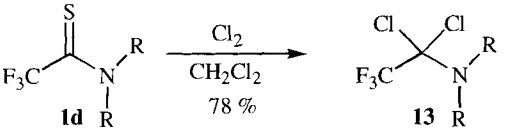




Scheme 3

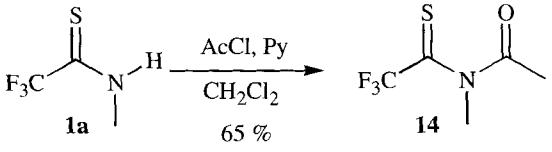
sis in absence of base, dithioesters **7** are obtained in 48-70% yield (Scheme 6, Tab. 2). All these dithioesters **7** are orange to red liquids or solids depending on the R^1 substituent.

Preparation of *tert*-butyl trifluorodithioacetate **7c** required the development of special reaction conditions. When *tert*-butylmercaptan was treated with **13** in chloroform, the reaction leads immediately and quantitatively to thioamide **1d** by elimination of HCl and isobutene (Scheme 7). This problem can be avoided by using ether as solvent at 0 °C.



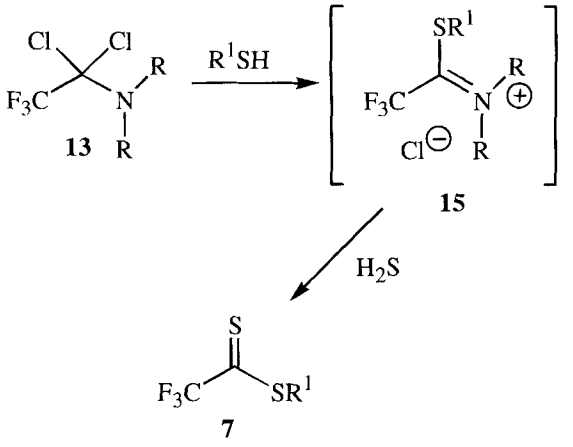
R = $-CH_2(CH_2)_3CH_2-$

Scheme 4

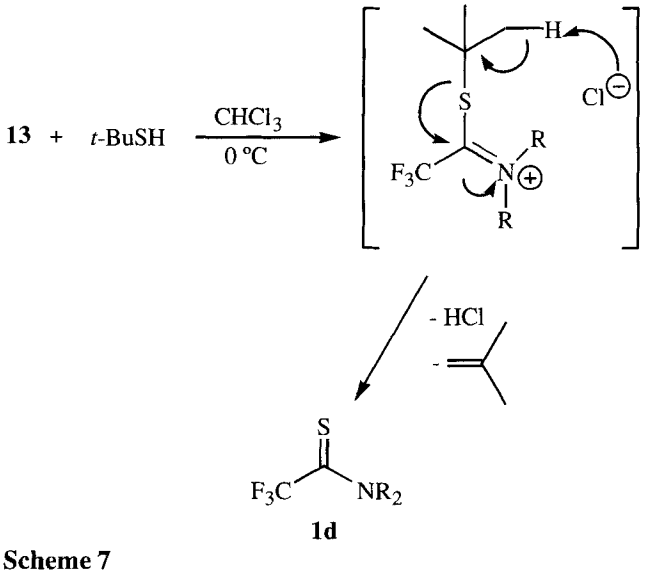


Scheme 5

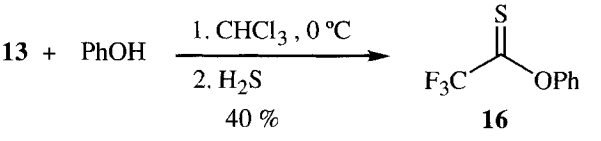
Reaction of aliphatic alcohols with **13** in chloroform or ether at 0 °C produced amide **10d** quantitatively [8], the use of phenol led to phenyl trifluorothionoacetate **16** in 40% yield.



Scheme 6

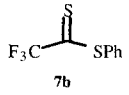
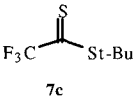
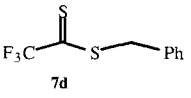
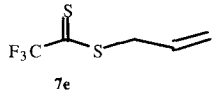
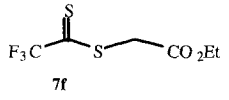
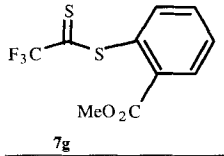


Scheme 7



Scheme 8

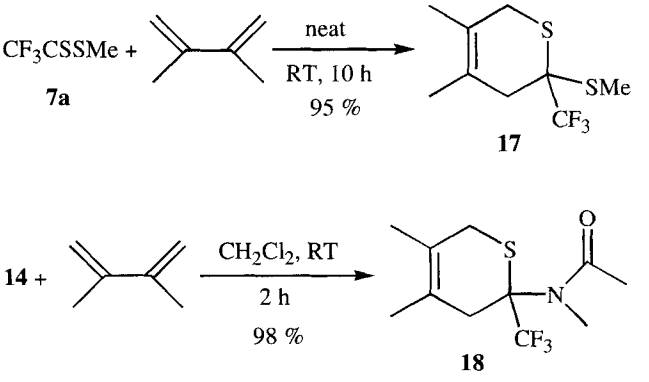
Tab. 2 Synthesis of trifluorodithioacetates **7b–g**

Trifluorodithioacetates	Yields %	*b.p* °C/mmHg
 **7b**	67	90–91/15
 **7c**	48 [a]	53–55/15
 **7d**	65	109/15
 **7e**	55	44/15
 **7f**	57	88/15
 **7g**	70	69/5 10^{-3} *m.p.* = 34 °C

[a]) solvent reaction is ether

Scheme 8

this activity by Diels–Alder reaction of **7a** with dimethyl butadiene. The thiopyran **17** is obtained in excellent yield. We have also found that thioimide **14** reacts rapidly with dimethyl butadiene, in absence of a Lewis acid [9], to give thiopyran **18** quantitatively.



Scheme 9

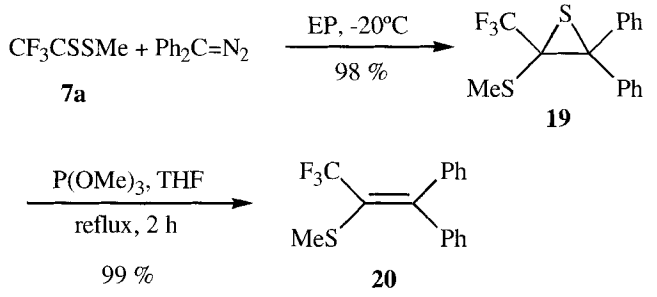
Cycloaddition Reactions

The dienophilic character of ethyl trifluorodithio-acetate had already been reported [6a]. We have confirmed

Thiocarbonyl compounds are well known as "superdipolarophiles" [10]. We envisaged that the electron withdrawing CF_3 group in trifluorodithioacetate **7** would

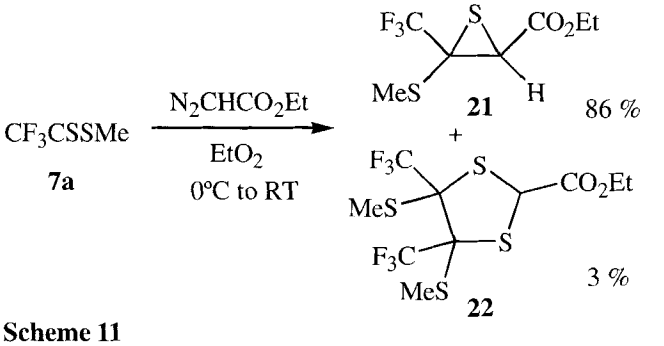
enhance this reactivity. Reaction of **7** with diazo compounds would provide a novel and rapid synthesis of trifluoromethyl vinyl sulphides. The synthesis of these interesting reagents [11] was readily exhibited.

Diphenyldiazomethane reacts instantaneously with **7a** in petroleum ether at –20 °C to form quantitatively thiirane **19** which is crystalline and stable at room temperature. Elimination of sulphur was performed by treatment of **19** with methylphosphite to give tetrasubstituted trifluoromethylated vinyl sulphide **20**.



Scheme 10

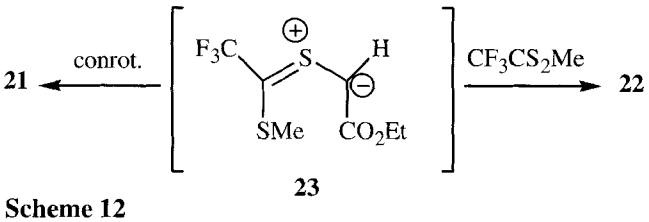
Cycloaddition reaction of **7a** with ethyl diazoacetate leads stereoselectively to thiirane **21** in 86% yield. Small quantities of dithiolane **22** could also be isolated.



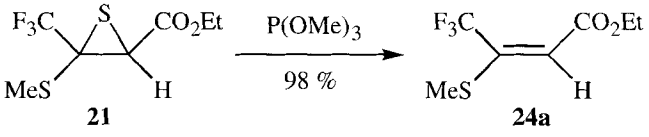
Scheme 11

This side reaction may proceed *via* a thiocarbonyl ylide **23** which can undergo either a conrotatory ring closure to give the thiirane **21** or a 1,3 dipolar cycloaddition with a second molecule of methyl trifluorodithioacetate **7a** to produce small quantities of **22**.

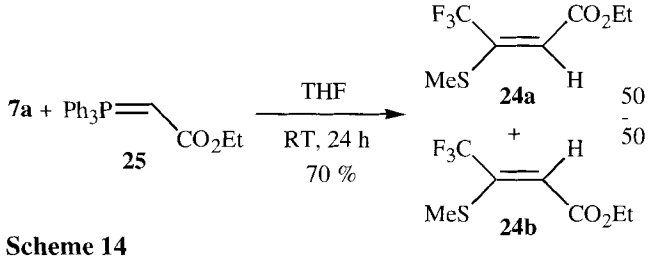
To confirm the stereochemistry of **21**, we have transformed the thiirane **21** in the *E*-olefin **24a** with methylphosphite. This reaction is known to proceed with retention of configuration. Its *Z*-isomer **24b** has also been prepared for comparative purposes by Wittig reaction of dithioester **7a** with phosphorane **25**. This olefination gives rise to both isomers in the same proportion in 70% yield [12].



Scheme 12

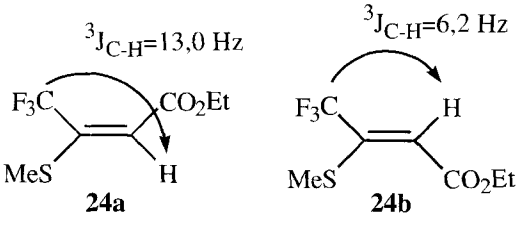


Scheme 13



Scheme 14

Comparison of coupling constants $^3J_{CF3\text{-}H}$ for **24a** and **24b** shows clearly that the CF_3 group is in *trans* position relative to the vinylic proton in **24a** ($^3J_{CF3\text{-}H}$ = 13,0 Hz).

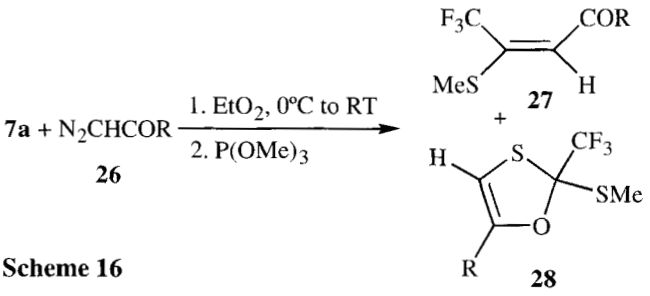


Scheme 15

Cycloadditions of **7a** with diazoketones **26a** or **26b** and subsequent sulphur elimination give the same stereoselectivity for the formation of the *E*-olefins. In these cases, the thiiranes cannot be isolated and new oxathioles **28** are also formed as by-products by 1,5 electrocyclisation of the 1,3 dipolar intermediates (Scheme 16 and Tab. 3).

Reaction of 7a with Nucleophiles

Depending on the nature of the nucleophile, either "thiophilic" or "carbophilic" addition is obtained.

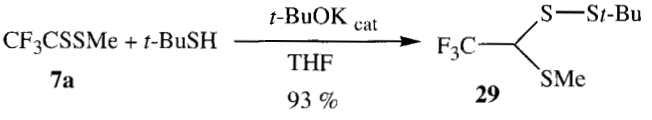


Scheme 16

Tab. 3 Vinyl sulphides **27** and oxathioles **28**

Entry	R	**27**%	**28**%
a	Ph	72	21
b	CH_2CH_2Ph	56	28

When **7a** reacts with *tert*-butylthiol in presence of a catalytic amount of base, the trifluoroethane dithioacetal disulfide **29** is formed resulting from "thiophilic" attack. It is interesting to note that no fluoride elimination is observed [6b].

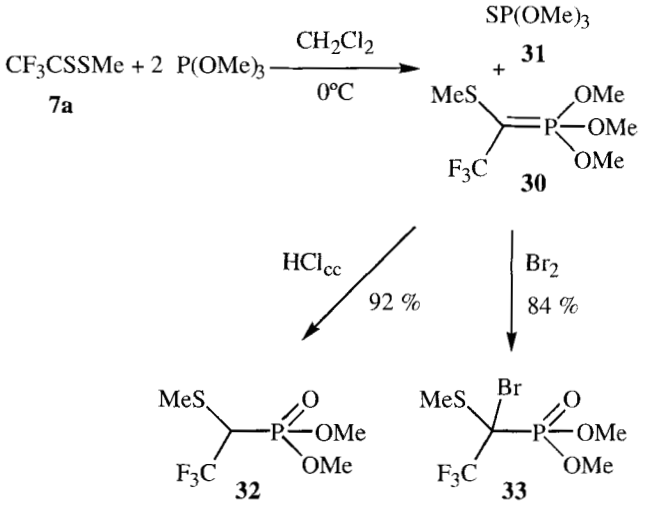


Scheme 17

The addition of the dithioacetate **7a** to two equivalents of methyl phosphite in CH_2Cl_2 at 0 °C leads quantitatively to the stabilised phosphonium ylide **30** and thio- phosphate **31**. The phosphonium ylide could be isolated by evaporation of the solvent and of the thiophosphate at reduced pressure. Reaction of **30** with concentrated hydrochloric acid or with bromine furnished the new trifluoromethylated phosphonates **32** or **33** in excellent yields.

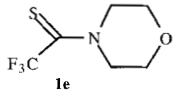
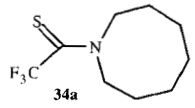
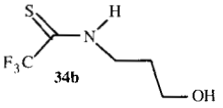
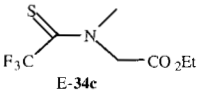
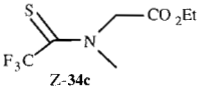
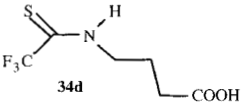
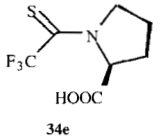
Amines including amino acids or derivatives lead to the corresponding trifluorothioacetamides **1e** or **34** by "carbophilic" addition. These reactions are rapid and allow access to new trifluorothioamides. Trifluorodithioacetate **7a** is thus a convenient trifluorothioacylating agent (Tab. 4). As described in the literature [13], only the *E* isomer (*N*-alkyl group *trans* to the C=S) is observed for the secondary thioamides. Similarly only the *E* isomer of the tertiary thioamide derived from proline is detected whilst the sarcosine derivative gives two isomers although NMR reveals that the *E* form predominates (*E*-*Z*/75-25).

In summary, the synthesis of the almost unknown trifluorodithioacetates is described by thiolysis of trifluorothioamidium salts. These dithioesters are highly reactive towards nucleophiles and in cycloaddition reactions and provide novel access to a series of interesting trifluoromethylated species.



Scheme 18

Tab. 4 Trifluorothioacetamides **1e**, **34a–e** from **7a**

Trifluorothioacetamides	Conditions	Yield
 **1e**	CH_2Cl_2 0 °C to RT 30 min	97
 **34a**	CH_2Cl_2 0 °C to RT 30 min	95
 **34b**	CH_2Cl_2 0 °C to RT 1 h	99
 E-**34c**		
 Z-**34c**	CH_2Cl_2 NEt_3 0 °C to RT 1 h	66
 **34d**	THF/H_2O NEt_3 1 h	42
 **34e**	THF/H_2O NEt_3 1 h	66

The authors are grateful to the Services de la Programmations de la Politique Scientifique (Belgium) and the Fonds National de la Recherche Scientifique (Belgium) for financial support.

Experimental

The ^{1}H NMR spectra were recorded on Varian Gemini-200 (200 MHz) and Gemini-300 (300 MHz) spectrometers using tetramethylsilane (TMS) as internal standard. The ^{13}C NMR spectra were recorded on Varian Gemini-200 (50 MHz) and Gemini-300 (75 MHz) spectrometers using $CDCl_3$ as reference. The ^{19}F NMR spectra were recorded on a Varian Gemini 300 (282 MHz) using $CFCl_3$ as the external standard ($\delta$are given in ppm and J in Hz). IR were recorded on a Nicolet-205-FT and a Bio-Rad FTS 135 apparatus. Mass spectra were recorded on a Varian Matt 44S and a Finnigan-Mat TSQ-70 apparatus and elemental analysis were carried out at University College London, London, UK. Melting points were determined with a Buchi apparatus in capillaries and are uncorrected. Column chromatography was performed with Merck silica gel 60 (70–230 mesh ASTM). All reaction solvents were dried and distilled according to standard procedures.

Trifluoroacetamides 10 (General Procedure)

Amine (1.0 mol) was added dropwise to ethyl trifluoroacetate (1.1 mol) at 0 °C (a dry ice condenser was used with gaseous amines). The mixture was allowed to warm to room temperature and stirred for 16 hours. The ethanol was removed under reduced pressure and the residue purified by fractional distillation to give the desired trifluoroacetamide.

N,N-Dimethyl-2,2,2-trifluoroacetamide (**10b**)

Yield 91%. *b.p.* 136 °C. – ^{19}F NMR ($CDCl_3$) δ –70.7. RN: 1682-66-2

N-(Trifluoroacetyl)-pyrrolidine (**10c**)

Yield 95%. *b.p.* 79 °C/15 mmHg. – ^{19}F NMR ($CDCl_3$) δ –72.9. RN: 6442-87-1

N-(Trifluoroacetyl)-piperidine (**10d**)

Yield 87%. *b.p.* 77 °C/15 mmHg. – ^{19}F NMR ($CDCl_3$) δ – 69.3. RN: 340-07-8

N-(Trifluoroacetyl)-morpholine (**10e**)

Yield 92%. *b.p.* 115–120 °C/15 mmHg. – ^{19}F NMR ($CDCl_3$) δ –69.0. RN: 360-95-2

Trifluorothioacetamides 1 (General Procedure)

A solution of trifluoroacetamide **10** (1.0 mol), P_4S_{10} (0.25 mol) and $NaHCO_3$ (1.0 g) in DME (400 ml) was heated at 60 °C for 2– 3 hours (completion of the reaction was verified by ^{19}F NMR). The mixture was cooled and filtered and the residue was washed with ether. The combined filtrates were evaporated and the crude product dissolved in diethyl ether (300 ml). The solution was washed with saturated $NaHCO_3$ solution, brine, water and dried ($MgSO_4$). The solvent was evaporated under reduced pressure and the residue was purified by distillation to give trifluorothioacetamide **1** as a yellow liquid or solid.

N-Methyl-2,2,2-trifluorothioacetamide (**1a**)

Yield 90%. *b.p.* 62 °C/15 mmHg. – ^{19}F NMR ($CDCl_3$) δ –70. RN: 65523-76-4

N,N-Dimethyl-2,2,2-trifluorothioacetamide (**1b**)

Yield 86%. *b.p.* 64 °C/15 mmHg. – ^{19}F NMR ($CDCl_3$) δ –62.6. RN: 79770-08-4

N-(2,2,2-Trifluoro-1-thioxoethyl)-pyrrolidine (**1c**)

(yellow solid) Yield 90%. *m.p.* 52–53 °C. *b.p.* 120 °C/15 mmHg. – IR (KBr) ν/cm^{-1} = 2995; 1490–1450; 1240–1110. – ^{19}F NMR ($CDCl_3$) δ–66.1. – ^{1}H NMR ($CDCl_3$) δ 2.08 (m, 4H); 3.85 (t, J=6.5, 4H). – ^{13}C NMR ($CDCl_3$) δ 22.93; 26.35; 51.83; 55.31; 117.03 (J_{C-F}= 279.2); 178.30 (J_{C-F}= 35.2). – MS (*m/e*) = 183 (M^+); 113; 69.

$C_6H_8F_3NS$	calcd:	C 39.34	H 4.40	N 7.65
	found:	C 39.47	H 4.36	N 7.54.

N-(2,2,2-Trifluoro-1-thioxoethyl)-piperidine (**1d**)

Yield 93%. *b.p.* 108–109 °C/15 mmHg. – IR (neat) ν/cm^{-1} = 2945; 1497–1442; 1220–1108. – ^{19}F NMR ($CDCl_3$) δ–62.1. – ^{1}H NMR ($CDCl_3$) δ 1.77 (m, 6H); 3.85 (m, 2H); 4.22 (m, 2H). – ^{13}C NMR ($CDCl_3$) δ 23.81; 25.04; 26.83; 52.68; 53.16 (J_{C-F}=3.6); 117.35 (J_{C-F}=279.8); 179.91 (J_{C-F}= 32.7. – MS (*m/e*) = 197 (M^+); 178; 113; 69.

$C_7H_{10}F_3NS$:	calcd.:	C 42.63	H 5.11	N 7.10
	found:	C 42.20	H 4.89	N 6.70.

N-(2,2,2-Trifluoro-1-thioxoethyl)-morpholine (**1e**)

(yellow solid) Yield 88%. *m.p.* 42 °C. – ^{19}F NMR ($CDCl_3$) δ–61.6. RN: 4675-80-3

N-Methyl-N-trifluorothioacetyl-acetamide (**14**)

A solution of acetyl chloride (3.30 g, 41.95 mmol) in dichloromethane (20 ml) was added dropwise to a solution of *N*-methyl trifluorothioacetamide **1a** (5.00 g, 34.96 mmol) and triethylamine (4.25 g, 41.95 mmol) in dry dichloromethane (80 ml) at 0 °C. The mixture was stirred at room temperature for 30 min and the solvent evaporated at reduced pressure. Diethylether (50 ml) was added and the mixture was filtered through Celite. The filtrate was washed with HCl (10%, 10 ml) and brine and dried ($MgSO_4$). The solvents were evaporated under reduced pressure and the residue purified by column chromatography on silica gel (eluent: CH_2Cl_2) to give the title compound (4.21 g, 65%) as an orange liquid. Yield 65%. *b.p.* 25 °C/5 10^{-3} mmHg. IR (neat) ν/cm^{-1} = 2991–2941; 1717; 1373; 1293–1144. – ^{19}F NMR ($CDCl_3$) δ–62.4. – ^{1}H NMR ($CDCl_3$) δ 2.48 (s, 3H); 3.50 (q, J_{H-F}= 0.73, 3H). – ^{13}C NMR ($CDCl_3$) δ 24.40; 38.23; 117.03 (J_{C-F}=279.5); 172.85; 190.95 (J_{C-F} = 37.3). – MS (*m/e*) = 185 (M^+); 143; 113; 69; 43.

$C_5H_6F_3NOS$	calcd:	C 32.43	H 3.27	N 7.56
	found:	C 32.60	H 3.21	N 7.57.

Methyl Trifluorodithioacetate (**7a**)

Procedure A: Methyl triflate (1.1 equivalent) was added to a solution of trifluorothioacetamide **1** (10 g) in dry dichloromethane (15 ml) *via* a syringe and under argon. The mixture was stirred at room temperature until reaction was complete (2 hours) and dry dichloromethane (35 ml) was added to the solution. The mixture was cooled to 0 °C and a stream of H_2S

was bubbled through the solution until a red colour appeared. The mixture was stirred for 15 min at room temperature and the solution was washed with HCl (10%, 10 ml), brine and water. The organic phase was dried ($MgSO_4$) and the solvent was evaporated carefully under reduced pressure. The red liquid was immediately distilled.

Procedure B: *N,N*-dimethyl Trifluorothioacetamide **1b** (130.4 g, 0.83 mol) and dimethyl sulfate (130 g, 1.03 mol) were heated at 80–85 °C under argon for 3 hours (completion of reaction was confirmed by ^{19}F NMR). The mixture was cooled and dry dichloromethane (500 ml) was added to the mixture The thiolysis was carried out as described in procedure A.

Yield 60–70%. *b.p.* 115 °C. IR (neat) ν/cm^{-1} = 2922; 1262; 1200–1109. – ^{19}F NMR ($CDCl_3$) δ –65.6. – ^1H NMR ($CDCl_3$) δ 2.72 (q, J_{H-F} = 0.3, 3H). – ^{13}C NMR ($CDCl_3$) δ 19.15; 118.11 (J_{C-F} = 279.5); 212.78 (J_{C-F} = 35.7). – MS (*m/e*) = 160 (M^+); 113; 69.

N-(1,1,1-Trifluoro-2,2-dichlororoethyl)-piperidine (**13**)

A solution of thioamide **1d** (20g, 0.10 mol) in dry dichloromethane (300 ml) was saturated with chlorine until the exothermic reaction has subsided. The mixture was stirred at room temperature for 2 hours and the solvent was evaporated under reduced pressure. The residue was further purified by distillation. A small amount of amide **10d** was always obtained with the desired amide chloride **13**. Yield 78%. *b.p.* 72 °C/15 mmHg. IR (neat) ν/cm^{-1} = 2944; 1697; 1277–1114. – ^{19}F NMR ($CDCl_3$) δ –71.8. – ^1H NMR ($CDCl_3$) δ 1.52 (m, 2H); 1.67 (m, 4H); 3.00 (t, J = 5.5, 4H). – ^{13}C NMR ($CDCl_3$) δ 23.56; 25.03; 48.93; 103.94 (J_{C-F} = 35.5); 120.72 (J_{C-F} = 284.0). – MS (*m/e*) = 235 (M^+); 202; 200; 164; 69.

Trifluorodithioacetate 7 (General Procedure)

Amide chloride **13** (3 g, 12.71 mmol) was added, under argon, to a cooled (0 °C) solution of thiol (15.25 mmol) in dry chloroform (25 ml). After one minute, H_2S was bubbled through the mixture (about 5 bubbles/second). The solution turned immediately to orange or red. After 3 min, thiolysis was stopped and HCl (10%, 10 ml) was added. The organic phase was washed with HCl (10%), brine and water and dried ($MgSO_4$). The solvent was evaporated under reduced pressure and the residue was immediately purified by distillation or chromatography on silica gel (eluent: petroleum ether) to afford the dithioester **7**.

Phenyl trifluorodithioacetate (**7b**)

Yield 67%. *b.p.* 90–91 °C/15 mmHg. IR (neat) ν/cm^{-1} = 3000; 1268; 1149; 1113; 904. – ^{19}F NMR ($CDCl_3$) δ –65.3. – ^1H NMR ($CDCl_3$) δ 7.48 (m, 5H). – ^{13}C NMR ($CDCl_3$) δ 118.40 (J_{C-F} = 280.5); 127.27; 130.28; 131.28; 134.77; 212.38 (J_{C-F} = 34.6). – MS (*m/e*) = 222 (M^+); 153; 113; 109; 69.

$C_8H_5F_3S_2$ calcd.: C 43.24 H 2.27
found: C 42.62 H 2.26.

tert-Butyl trifluorodithioacetate (**7c**)

The reaction was carried out in dry diethyl ether (40 ml) Yield 48%. *b.p.* 53 °C/15 mmHg. IR (neat) ν/cm^{-1} = 2970; 1245; 1151; 1108; 908. – ^{19}F NMR ($CDCl_3$) δ –66.3. – ^1H NMR ($CDCl_3$) δ 1.64 (s, 9H). – ^{13}C NMR ($CDCl_3$) δ 27.69; 53.14; 117.57 (J_{C-F} = 279.8); 212.25 (J_{C-F} = 33.9). – MS (*m/e*): 202 (M^+); 113; 69; 57.

$C_6H_9F_3S_2$ calcd.: C 35.63 H 4.49
found: C 35.58 H 4.34.

Benzyl trifluorodithioacetate (**7d**)

Yield 65%. *b.p.* 109 °C/15 mmHg. – IR (neat) ν/cm^{-1} = 1260; 1150; 1108; 924. – ^{19}F NMR ($CDCl_3$) δ –65.5. – ^1H NMR ($CDCl_3$) δ 4.45 (s, 2H); 7.34 (s, 5H). – ^{13}C NMR ($CDCl_3$) δ 41.25; 118.16 (J_{C-F} = 279.8); 128.39; 128.95; 129.18; 132.79; 211.12 (J_{C-F} = 35.9). – MS (*m/e*) = 236 (M^+); 113; 91; 77; 69.

$C_9H_7F_3S_2$: calcd.: C 45.75 H 2.99
found: C 45.60 H 3.24.

Allyl trifluorodithioacetate (**7e**)

Yield 55%. *b.p.* 44 °C/15 mmHg. – IR (neat) ν/cm^{-1} = 1262; 1151; 1109; 918. – ^{19}F NMR ($CDCl_3$) δ –65.2. – ^1H NMR ($CDCl_3$) δ 3.93 (d, ^3J = 6.9, 2H); 5.31 (dq, ^3J = 10.0, $^2J = {}^4J$ = 1.2, 1H); 5.42 (dq, ^3J = 16.9, $^2J = {}^4J$ = 1.2, 1H); 5.85 (ddt, ^3J = 16.9, ^3J = 10.0, ^3J = 6.9, 1H). – ^{13}C NMR ($CDCl_3$) δ 38.80; 118.08 (J_{C-F} = 279.8); 121.36; 128.44; 211.10 (J_{C-F} = 36.1). – MS (*m/e*) = 186 (M^+); 113; 73; 69.

Ethyl (2-trifluorodithioacetyl)-ace te (**7f**)

Yield 57%. *b.p.* 88 °C/15 mmHg. IR (neat) ν/cm^{-1} = 1741; 1262; 1155; 1110. – ^{19}F NMR ($CDCl_3$) δ – 65.5. – ^1H NMR ($CDCl_3$) δ 1.30 (t, J = 7.1, 3H); 4.10 (s, 2H); 4.23 (q, J = 7.1, 2H). – ^{13}C NMR ($CDCl_3$) δ 13.87; 38.07; 62.39; 118.06 (J_{C-F} = 279.8); 165.44; 210.59 (J_{C-F} = 36.1). – MS (*m/e*) = 232 (M^+); 187; 159; 119; 113; 69; 45.

$C_6H_7F_3O_2S_2$ calcd.: C 31.03 H 3.04
found: C 30.77 H 3.02.

Methyl (2-trifluorodithioacetyl)-benzoate (**7g**)

(red solid) Yield 70%. *m.p.* 34 °C. *b.p.* 69° C/5×10^{-3} mmHg. IR (KBr) ν/cm^{-1} = 1732; 1259; 1151; 1111; 909. – ^{19}F NMR ($CDCl_3$) δ – 64.7. – ^1H NMR ($CDCl_3$) δ 3.86 (s, 3H); 7.61 (m, 3H); 8.13 (m, 1H). – ^{13}C NMR ($CDCl_3$) δ 52.54; 118.28 (J_{C-F} = 280.5); 127.71; 131.39; 131.98; 133.19; 134.82; 136.89; 210.58 (J_{C-F} = 34.4). – MS (*m/e*) = 280 (M^+); 249; 221; 167; 152; 136; 113; 109; 69.

$C_{10}H_7F_3O_2S_2$ calcd.: C 42.85 H 2.52
found: C 42.58 H 2.61.

Phenyl trifluorothionoacetate (**16**)

Amide chloride **13** (3.00g, 12.71 mmol) was added under argon to a cooled (0 °C) solution of phenol (1.43 g, 15.21 mmol) in dry chloroform (25 ml). After 5 min, H_2S was bubbled through the mixture (about 5 bubbles/second). The solution immediately turned bright yellow. Bubbling was continued for 3 min, after which thiolysis was stopped and HCl (10%, 10 ml) was added. The organic phase was washed with HCl (10%), brine, water and dried ($MgSO_4$). The solvent was evaporated under reduced pressure and the residue was immediately purified by chromatography on silica gel (eluent: petroleum ether) to afford **16**. Yield 40%. *b.p.* 56 °C/15 mmHg. IR (neat) ν/cm^{-1} = 1269; 1220; 1156; 1055. – ^{19}F NMR ($CDCl_3$) δ 71.2. – ^1H NMR ($CDCl_3$) δ 7.31 (m, 5H). – ^{13}C NMR ($CDCl_3$) δ 116.06 (J_{C-F} = 279.8); 120.97; 127.46; 130.11; 153.03; 195.30 (J_{C-F} = 39.5). – MS (*m/e*) = 206 (M^+); 133; 77; 69.

$C_8H_5F_3OS$ calcd.: C 46.60 H 2.44
found: C 46.44 H 2.43.

Cycloaddition Reactions of 7a

2-(Methylthio)-3,6-dihydro-4,5-dimethyl-2-(trifluoro-methyl) thiopyran (**17**)

A mixture of methyl trifluorodithioacetate (**7a**) (0.50 g, 3.12 mmol) and 2,3-dimethylbutadiene (0.51 g, 6.25 mmol) was stirred at room temperature for 10 hours. The excess diene was evaporated under reduced pressure and the residue was further purified by distillation under reduced pressure to yield the title compound **17** (0.72 g, 95%). *b.p.* 55 °C/0.2 mmHg. IR (neat) ν/cm^{-1} = 2995–2924; 1442; 1266–1151. – ^{19}F NMR ($CDCl_3$) δ –73.8. – ^{1}H NMR ($CDCl_3$) δ 1.72 (s, 3H); 1.78 (s, 3H); 2.22 (d, ^2J = 17.2, 1H); 2.26 (q, J_{H-F} = 1.3, 3H); 2.80 (d, ^2J = 17.2, 1H); 2.90 (d, ^2J = 16.4, 1H); 3.30 (d, ^2J = 16.4, 1H). – ^{13}C NMR ($CDCl_3$) δ 14.06; 18.75; 19.67; 29.43; 36.78; 58.50 (J_{C-F} = 33.7); 122.90; 123.65; 126.86 (J_{C-F} = 281.7). – MS (*m/e*) = 242 (M^+); 195; 194; 179.

$C_9H_{13}F_3S_2$ calcd.: C 44.61 H 5.41 S 26.46
found: C 44.68 H 5.31 S 26.81.

N-Methyl-N-(2-trifluoromethyl-3,6-dihydro-2H-thiopyran-2-yl) acetamide (**18**)

A mixture of thioimide **14** (0.3 g, 1.62 mmol) and dimethyl butadiene (0.16 g, 1.95 mmol) in dichloromethane (1 ml) was stirred at room temperature for 2 hours. The solvent was evaporated and the product was purified by horizontal distillation. Yield 98%. *b.p.* 50 °C/1.4×10^{-3}. – IR (neat) ν/cm^{-1} = 2919; 1681; 1273–1143. – ^{19}F NMR ($CDCl_3$) δ –74.7. – ^{1}H NMR ($CDCl_3$) δ 1.74 (s, 6H); 2.16 (s, 3H); 2.88 (d, J = 15.7, 1H); 3.03 (d, J = 15.7, 1H); 3.13 (d, J = 16.1, 1H); 3.26 (s, 3H); 3.89 (d, J = 16.1, 1H). – ^{13}C NMR ($CDCl_3$) δ 18.25; 19.24; 25.48; 31.40; 35.52; 36.50; 71.87 (J_{C-F} = 27.7); 123.73; 124.90; 125.64 (J_{C-F} = 287.8). – MS (*m/e*) = 268 (M^+); 224; 194; 179; 74; 69; 43.

$C_{11}H_{16}F_3NOS$ calcd.: C 49.43 H 6.03 N 5.24 S 11.99
found: C 48.99 H 6.00 N 5.26 S 11.97.

3-(Methylthio)-2,2-diphenyl-3-(trifluoromethyl)-thiirane (**19**)

A mixture of benzophenone hydrazone (0.80 g, 4.06 mmol), yellow HgO (0.88 g, 4.06 mmol) and petroleum ether (4 ml) was stirred at room temperature for 6 hours. The suspension was filtered and the residue was washed with petroleum ether (10 ml). The combined filtrate were cooled to –20 °C and methyl trifluorodithioacetate **7a** (0.74 g, 4.07 mmol), was added dropwise to the solution. A vigorous evolution of gas occurred during the addition. The reaction mixture was warmed to room temperature and then evaporated to dryness under reduced pressure to give a solid residue. Recrystallisation from hexane afforded thiirane **19** (1.49 g, 98%) as a white solid. *m.p.* 67–68 °C. – IR (KBr) ν/cm^{-1} = 3061–3008; 2926; 1446; 1267–1145. – ^{19}F NMR ($CDCl_3$) δ –62.9. – ^{1}H NMR ($CDCl_3$) δ 2.29 (q, J_{H-F} = 1.0, 3H); 7.38 (m, 10H). – ^{13}C NMR ($CDCl_3$) δ 18.80; 61.86 (J_{C-F} = 34.4); 70.18; 125.15 (J_{C-F} = 278.5); 127.71; 128.07; 128.13; 128.57; 128.60; 128.93; 139.54; 140.49. – MS (*m/e*) = 326 (M^+); 279; 210; 178.

$C_{16}H_{13}F_3S_2$ calcd.: C 58.88 H 4.01 S 19.64
found: C 58.58 H 4.10 S 19.54.

3,3,3-Trifluoro-2-(methylthio)-1,1-diphenyl-prop1-ene (**20**)

A mixture of thiirane **19** (0.30 g, 0.92 mmol), trimethylphosphite (0.17 g, 1.38 mmol) and THF (1 ml) was heated at reflux for 2 hours. After evaporation of solvent, the trimethylphosphite and the thiophosphate were removed by horizontal distillation under reduced pressure (30 °C/0.1 mmHg). The product was purified by chromatography on silica gel. Yield 99%. – IR (neat) ν/cm^{-1} = 3058; 2927; 1560; 1256–1119. – ^{19}F NMR ($CDCl_3$) δ –56.0. – ^{1}H NMR ($CDCl_3$) δ 2.17 (s, 3H); 7.24 (m, 10H). – ^{13}C NMR ($CDCl_3$) δ 18.78; 123.71 (J_{C-F} = 275.5); 124.62 (J_{C-F} = 30.5); 127.99; 128.20; 128.21; 128.27; 128.41; 128.92; 140.58; 141.60; 155.00 ($^3J_{C-F}$ = 2.8). – MS (*m/e*) = 294 (M^+); 279; 210.

$C_{16}H_{13}F_3S$ calcd.: C 65.29 H 4.45 S 10.89
found: C 65.02 H 4.15 S 11.26.

Reaction of **7a** *with Ethyl Diazoacetate*

Methyl trifluorodithioacetate **7a** (1.2 g, 7.5 mmol) was added to a cooled (0 °C) solution consisting of ethyl diazoacetate (90%, 0.95 g, 7.5 mmol) in diethyl ether (10 ml). The reaction mixture was slowly warmed to room temperature and then stirred for 3 hours (until the red colour disappeared). After quenching with HCl (5%), the organic phase was washed with water and dried ($MgSO_4$). Chromatography on silica gel afforded thiirane **21** (1.59 g, 86%) and dithiolane **22** (0.091 g, 3%).

Ethyl 3-(methylthio)-3-(trifluoromethyl)-thiirane-2-carboxylate (**21**)

IR (neat) ν/cm^{-1} = 2930; 1745; 1244–1108. – ^{19}F NMR ($CDCl_3$) δ – 66.2. – ^{1}H NMR ($CDCl_3$) δ 1.29 (t, J = 7.1, 3H); 2.41 (s, 3H); 3.93 (s, 1H); 4.26 (m, 2H). – ^{13}C NMR ($CDCl_3$) δ 13.60; 17.94; 46.99; 51.80 (J_{C-F} = 37.4); 62.70; 124.24 (J_{C-F} = 278.1); 163.90. – MS (*m/e*) = 246 (M^+); 199; 171; 69.

Ethyl 4,5-bis(methylthio)-4,5-bis(trifluoromethyl)-1,3-dithiolane-2-carboxylate (**22**)

IR (neat) ν/cm^{-1} = 2988–2929; 1741; 1226–1018. – ^{19}F NMR ($CDCl_3$) δ – 65.6; – 67.8. – ^{1}H NMR ($CDCl_3$) δ 1.33 (t, J = 7.1, 3H); 2.37 (s, 3H); 2.47 (s, 3H); 4.31 (m, 2H); 5.27 (s, 1H). – ^{13}C NMR ($CDCl_3$) δ 13.75; 14.94; 18.55; 61.71; 63.30; 72.12 (J_{C-F} = 32.1); 77.53 (J_{C-F} = 27.4); 124.51 (J_{C-F} = 285.4); 124.54 (J_{C-F} = 282.0); 163.52. – MS (*m/e*) = 406 (M^+); 359; 311; 283; 239.

Ethyl (E)-4,4,4-trifluoro-3-(methylthio)but-2-enoate (**24a**)

A mixture of thiirane **21** (0.30 g, 1.22 mmol) and trimethylphosphite (0.185 g, 2.44 mmol) was stirred at room temperature for 1 hour. The trimethylphosphite and thiophosphate were removed by horizontal distillation under reduced pressure (30 °C/0.1 mmHg). The residue was purified by chromatography on silica gel to give the title compound (0.26 g, 98%). IR (neat) ν/cm^{-1} = 2987; 1732; 1245–1166. – ^{19}F NMR ($CDCl_3$) δ – 61.2. – ^{1}H NMR ($CDCl_3$) δ 1.31 (t, J = 7.1, 3H); 2.35 (s, 3H); 4.23 (q, J = 7.1, 2H); 5.71 (s, 1H). – ^{13}C NMR ($CDCl_3$) δ 13.78; 15.03; 61.06; 116.95; 121.01 (J_{C-F} = 276.9, $^3J_{C-H}$ = 13.0); 144.31 (J_{C-F} = 34.3); 162.42. – MS (*m/e*) = 214 (M^+); 199; 168; 140; 71; 69.

$C_7H_9F_3O_2S$ calcd.: C 39.25 H 4.23 S 14.97
found: C 39.27 H 4.16 S 14.73.

Ethyl (Z)-4,4,4-trifluoro-3-(methylthio)but-2-enoate (**24b**)

A mixture of methyl trifluorodithioacetate **7a** (0.50 g, 3.16 mmol) and phosphorane **25** (1.00 g, 2.87 mmol) in dry THF (12 ml) was stirred at room temperature for 24 hours under argon. The solvent was evaporated under reduced pressure. The residue was stirred with petroleum ether (20 ml) and the solid was filtered and washed with petroleum ether. The combined filtrates were evaporated to dryness and the residue purified by column chromatography on silica gel to give the *E* isomer **24a** (0.22 g, 35%) and the *Z* isomer **24b** (0.22 g, 35%). – ^{19}F NMR ($CDCl_3$) δ –62.6 ppm. – ^{1}H NMR ($CDCl_3$) δ 1.31 (t, J = 7.1, 3H); 2.48 (q, J_{H-F} = 1.6, 3H); 4.24 (q, J = 7.1, 2H); 6.46 (q, J_{H-F} = 1.1, 1H). – ^{13}C NMR ($CDCl_3$) δ 13.94; 15.31; 60.87; 118.52 (J_{C-F} = 6.0); 121.55 (J_{C-F} = 276.2, $^3J_{C-H}$ = 6.2); 144.30 (J_{C-F} = 31.1); 162.29.

Reactions of 7a with Diazoketones 26 (General Procedure)

Methyl trifluorodithioacetate **7a** (0.75 mmol) was added to a cooled (0 °C) solution of diazoketone **26** (0.68 mmol), prepared from the acid chloride and diazomethane [14], in diethyl ether (2 ml). The reaction mixture was slowly warmed to room temperature and then stirred 16 hours. The solvent was evaporated under reduced pressure. Trimethylphosphite (1.02 mmol) was added and the mixture was stirred for 1 hour. Trimethylphosphite and thiophosphate were removed by horizontal distillation under reduced pressure (30 °C/0.1 mmHg) and then the residue was purified by chromatography on silica gel.

(E)-4,4,4-Trifluoro-3-(methylthio)-1-phenyl-but-2-en-1-one (**27a**)

Yield 72%. – IR (neat) ν/cm^{-1} = 1668; 1598–1591; 1261–1142. – ^{19}F NMR ($CDCl_3$) δ –60.8. – ^{1}H NMR ($CDCl_3$) δ 2.45 (s, 3H); 6.48 (s, 1H); 7.45 (m, 5H). – ^{13}C NMR ($CDCl_3$) δ 15.39; 121.56 (J_{C-F} = 277.0, $^3J_{C-H}$ = 13.1); 125.25; 128.69; 128.86; 133.73; 136.45; 140.23 (J_{C-F} = 33.2); 189.63. MS (*m/e*) = 246 (M^+); 231; 105; 77.

$C_{11}H_9F_3OS$ calcd.: C 53.65 H 3.68 S 13.02
found: C 53.26 H 3.40 S 13.35.

2-(Methylthio)-5-phenyl-2-(trifluoromethyl)-1,3-oxathiole (**28a**)

Yield 21%. IR (neat) ν/cm^{-1} = 2925; 1692; 1279–1195. – ^{19}F NMR ($CDCl_3$) δ –77.5. – ^{1}H NMR ($CDCl_3$) δ 2.38 (s, 3H); 6.02 (s, 1H); 7.42 (m, 5H). – ^{13}C NMR ($CDCl_3$) δ 12.73; 94.25; 104.55 (J_{C-F} = 32.8); 123.09 (J_{C-F} = 282.9); 124.73; 128.63; 128.86; 131.53; 148.98. – MS (*m/e*) = 278 (M^+); 231; 134; 105; 77; 69.

(E)-6,6,6-Trifluoro-5-methylthio-1-phenylhex-4-en-3-one (**27b**)

Yield 56%. – IR (neat) ν/cm^{-1} = 3028; 2925; 1701; 1576; 1261–1144. – ^{19}F NMR ($CDCl_3$) δ –60.9. – ^{1}H NMR ($CDCl_3$) δ 2.27 (s, 3H); 2.90 (t, J = 5.6, 2H); 2.93 (t, J = 5.6, 2H); 5.86 (s, 1H); 7.24 (m, 5H). – ^{13}C NMR ($CDCl_3$) δ 15.03; 29.78; 44.90; 121.31 (J_{C-F} = 277.2, $^3J_{C-H}$ = 14.0); 125.78 (J_{C-F} = 2.2); 126.09; 128.18; 128.38; 140.46; 140.68 (J_{C-F} = 34.7); 196.02. – MS (*m/e*) = 274 (M^+); 227; 169; 141; 91; 77.

$C_{13}H_{13}F_3OS$ calcd.: C 56.92 H 4.78 S 11.69
found: C 56.60 H 4.72 S 11.84.

2-(Methylthio)-5-(2-phenylethyl)-2-(trifluoro-methyl)-1,3-oxathiole (**28b**)

Yield 28%. – IR (neat) ν/cm^{-1} = 3028; 2928; 1664; 1274–1176. – ^{19}F NMR ($CDCl_3$) δ –77.5. – ^{1}H NMR ($CDCl_3$) δ 2.32 (s, 3H); 2.52 (t, J = 6.7, 2H); 2.85 (t, J = 6.7, 2H); 5.23 (s, 1H); 7.25 (m, 5H). – ^{13}C NMR ($CDCl_3$) δ 12.70; 30.03; 32.81; 93.25; 104.29 (J_{C-F} = 34.4); 123.09 (J_{C-F} = 282.6); 126.27; 128.25; 128.42; 140.21; 150.20. – MS (*m/e*) = 306 (M^+); 259; 227; 77.

Reactions of **7a** with Nucleophiles

2-(tert-Butyldithio)-2-methylthio-1,1,1-trifluoro-ethane (**29**)

A mixture consisting of methyl trifluorodithioacetate **7a** (0.50 g, 3.13 mmol), *tert*-butylthiol (0.31 g, 3.44 mmol) and *t*-BuOK (0.018 g, 0.16 mmol) in dry THF (5 ml) was stirred at room temperature for 2 hours. Water (5 ml) was added and the product was extracted with dichloromethane. The organic phase was washed with water and dried ($MgSO_4$) and the disulphide **29** was distilled horizontally. Yield 93%. *b.p.* 40 °C/0.1 mmHg. IR (neat) ν/cm^{-1} = 2964–2864; 1292–1102. – ^{19}F NMR ($CDCl_3$) δ –68.1 (d, J_{F-H} = 7.4). – ^{1}H NMR ($CDCl_3$) δ 1.39 (s, 9H); 2.35 (s, 3H); 4.04 (q, J_{H-F} = 8.0, 1H). – ^{13}C NMR ($CDCl_3$) δ 14.79; 29.54; 48.59; 60.84 (J_{C-F} = 29.5); 125.22 (J_{C-F} = 280.7). – MS (*m/e*) = 250 (M^+); 228; 161; 129; 89.

$C_7H_{13}F_3S_3$ calcd.: C 33.58 H 5.23 S 38.42
found: C 33.82 H 5.10 S 38.06.

Dimethyl 1-(methylthio)-2,2,2-trifluoroethyl-phosphonate (**32**)

Methyl trifluorodithioacetate **7a** (0.50 g, 3.13 mmol) was added dropwise to a cooled (0 °C) solution of trimethylphosphite (0.81 g, 6.56 mmol) in dry dichloromethane (5 ml). The mixture was stirred for 30 min at 0 °C after which concentrated HCl (0.5 ml) was added dropwise and the mixture was stirred for 5 min. The organic phase was washed with water and with a saturated solution of $NaHCO_3$ and dried ($MgSO_4$). The solvent was evaporated and the thiophosphate was removed by horizontal distillation under reduced pressure (30 °C/0.1 mmHg). The residue was purified by chromatography on silica gel (eluent: ether). Yield 92%. – IR (neat) ν/cm^{-1} = 2962; 1299–104; 1035. – ^{19}NMR ($CDCl_3$) δ –63.5 (dd, J_{F-H} = 7.9, J_{F-P} = 8.2). – ^{1}H NMR ($CDCl_3$) δ 2.40 (s, 3H); 3.33 (dq, J_{H-P} = 21.9, J_{H-F} = 9.2, 1H); 3.87 (d, J_{H-P} = 3.9, 3H); 3.92 (d, J_{H-P} = 3.8, 3H). – ^{13}C NMR ($CDCl_3$) δ 16.79; 43.84 (J_{C-P} = 146.4, J_{C-F} = 35.5); 53.91 (J_{C-P} = 6.7); 54.24 (J_{C-P} = 7.0); 124.47 (J_{C-F} = 279.1). – MS (*m/e*) = 238 (M^+); 192; 162; 79; 69; 47; 31.

$C_5H_{10}F_3O_3PS$ calcd.: C 25.22 H 4.23
found: C 25.29 H 4.30.

Dimethyl 1-bromo-1-(methylthio)-2,2,2-trifluoroethylphosphonate (**33**)

Methyl trifluorodithioacetate **7a** (0.50 g, 3.13 mmol) was added dropwise to a cooled (0 °C) solution of trimethylphosphite (0.81 g, 6.56 mmol) in dry dichloromethane (5 ml). The mixture was stirred for 30 min at 0 °C after which bromine (0.5 g, 3.13 mmol) was added dropwise and the mixture was stirred for 5 min. The organic phase was washed with water

and with a saturated solution of $NaHCO_3$ and dried ($MgSO_4$). The solvent was evaporated and the thiophosphate was removed by horizontal distillation under reduced pressure (30 °C/ 0.1 mmHg). The residue was purified by chromatography on silica gel (eluent: ether). Yield 84%. – IR (neat) ν/cm^{-1} = 2969; 1225–176; 1053. – ^{19}F NMR ($CDCl_3$) δ –66.5. – ^{1}H NMR ($CDCl_3$) δ 2.49 (s, 3H); 3.99 (d, J_{H-P} = 11.0, 3H); 4.00 (d, J_{H-P} = 11.0, 3H). – ^{13}C NMR ($CDCl_3$) δ 16.51; 55.73 (J_{C-P} = 3.3); 54.24 (J_{C-P} = 3.5); 61.41 (J_{C-P} = 151.5, J_{C-F} = 32.1); 122.91 (J_{C-F} = 282.5). MS (*m/e*) = 318 (M^++1); 316 (M^+–1); 270; 237; 190; 69; 47.

$C_5H_9BrF_3O_3PS$ calcd.: C 18.94 H 2.86
found: C 19.17 H 2.80.

Reaction of 7a with Amines (General Procedure)

Methyl trifluorodithioacetate **7a** (1.00 g, 6.25 mmol), was added to a solution of amine (5.33 mmol) -triethyl amine (5.33 mmol) was used with ammonium salts- in dry dichloromethane (30 ml). After 30 to 60 min, the orange colour has turned to yellow and the solvent was evaporated. The thioamide was purified by distillation or chromatography on silica gel.

N-(2,2,2-Trifluoro-1-thioxoethyl)-heptamethylene-imine (**34a**)

Yield 95%. *b.p.* 40 °C/0.05 mmHg. IR (neat) ν/cm^{-1} = 2930; 1460–1423; 1266–1135. – ^{19}F NMR ($CDCl_3$) δ –61.1. – ^{1}H NMR ($CDCl_3$) δ 1.60 (m, 6H); 1.90 (m, 2H); 2.00 (m, 2H); 3.79 (t, J = 5.7, 2H); 4.04 (m, J = 6.3, 2H). – ^{13}C NMR ($CDCl_3$) δ 22.49; 22.76; 23.31; 25.50; 26.35; 55.00; 56.10 (J_{C-F} = 3.9); 117.40 (J_{C-F} = 279.4); 180.97 (J_{C-F} = 33.9). – MS (*m/e*) = 225 (M^+); 192; 113; 69.

$C_9H_{14}F_3NS$ calcd.: C 47.99 H 6.26 N 6.22
found: C 48.10 H 6.25 N 6.17.

2,2,2-Trifluoro-N-(3-hydroxypropyl)thioacetamide (**34b**)

Yield 99%. – IR (neat) ν/cm^{-1} = 3959; 2954; 1538; 1418; 1288–1155. – ^{19}F NMR ($CDCl_3$) δ –70.5. – ^{1}H NMR ($CDCl_3$) δ 1.91(s, 1H); 1.96 (m, 2H); 3.83 (td, J = 5.3, J = 6.2, 2H); 3.93 (t, J = 5.3, 2H); 9.35 (s, 1H). – ^{13}C NMR ($CDCl_3$) δ 28.58; 44.47; 60.89; 117.19 (J_{C-F} = 279.6); 182.74 (J_{C-F} = 35.6). – MS (*m/e*) = 187 (M^+); 154; 143; 113; 69.

$C_5H_8F_3NOS$ calcd.: C 32.08 H 4.31 N 7.48
found: C 31.58 H 4.06 N 7.34.

Ethyl (methyl-trifluorothioxoethyl-amino)-acetate (**34c**)

Yield 66%. *b.p.* 120 °C/15 mmHg. IR (neat) ν/cm^{-1} = 1748; 1507; 1401; 1270–1103; 1036. isomer *E*: – ^{19}F NMR ($CDCl_3$) δ –62.57. – ^{1}H NMR ($CDCl_3$) δ 1.30 (t, J = 7.1, 3H); 3.51 (q, J_{H-F} = 1.3, 3H); 4.25 (q, J = 7.1, 2H); 4.62 (s, 2H). – ^{13}C NMR ($CDCl_3$) δ 13.81; 42.18 (J_{C-F} = 4.4); 58.04; 61.62; 117.12 (J_{C-F} = 279.4); 165.76; 183.53 (J_{C-F} = 34.9), isomer *Z*. – ^{19}F NMR δ –63.3. – ^{1}H NMR δ/ppm = 1.30 (t, J = 7.1, 3H); 3.49 (s, 3H); 4.27 (q, J = 7.1, 2H); 4.49 (q, J_{H-F} = 1.1, 2H). – ^{13}C NMR δ 13.81; 45.08; 55.65 (J_{C-F} = 3.8); 62.00; 117.00 (J_{C-F} = 279.1); 166.42; 183.00 (J_{C-F} = 31.3). – MS (*m/e*) = 229 (M^+); 196; 168; 156; 113; 69.

$C_7H_{10}F_3NO_2S$ calcd.: C 36.68 H 4.40 N 6.11 S 13.99
found: C 36.58 H 4.33 N 5.94 S 14.00.

Reaction of 7a with Amino Acids (General Procedure)

A mixture of amino acid (6.25 mmol), triethyl amine (0.63 g, 6.25 mmol), methyl trifluorodithioacetate **7a** (1.00 g, 6.25 mmol), THF (35 ml) and water (5 ml) was stirred at room temperature for 1 hour. The reaction mixture was washed with HCl (2M) and water. The organic phase was dried (Na_2SO_4) and evaporated to dryness to give a yellow oil which crystallised slowly. The solid was recrystallised from hexane.

4-(2,2,2-Trifluoro-thioacetylamino)-butyric acid (**34d**)

Yield 42%. *m.p.* 65 °C. – IR (KBr) ν/cm^{-1} = 3288–2953; 1708; 1542; 1432–1406; 1292–1150. – ^{19}F NMR ($CDCl_3$) δ –70.4. – ^{1}H NMR ($CDCl_3$) δ 2.08 (quint, J = 6.5, 2H); 2.59 (t, J = 6.5, 2H); 3.74 (dt, J = 6.5, J = 5.8, 2H); 8.76 (m, 2H). – ^{13}C NMR ($CDCl_3$) δ 22.02; 31.56; 45.48; 117.37 (J_{C-F} = 279.4); 178.42; 183.47 (J_{C-F} = 35.1). – MS (*m/e*) = 215 (M^+); 197; 113; 69.

$C_6H_8F_3NO_2S$ calcd.: C 33.49 H 3.75 N 6.51 S 14.90
found: C 33.71 H 3.69 N 6.37 S 14.83.

N-(2,2,2-Trifluoro-1-thioxoethyl)-L-proline (**34e**)

Yield 66%. *m.p.* 81–83 °C. – IR (KBr) ν/cm^{-1} = 2985; 1719; 1482–1452; 1290–1133. – ^{19}F NMR ($CDCl_3$) δ –66.4. – ^{1}H NMR ($CDCl_3$) δ 2.28 (m, 4H); 3.99 (m, 2H); 4.96 (dd, J = 8.2, J = 3.8, 1H); 8.15 (s, 1H). – ^{13}C NMR ($CDCl_3$) δ 25.18; 28.43; 52.36 (J_{C-F} = 3.5); 66.51; 117.16 (J_{C-F} = 280.1); 174.43; 180.92 (J_{C-F} = 36.6). – MS (*m/e*) = 227 (M^+); 182; 113; 44.

$C_7H_8F_3NO_2S$ calcd.: C 37.01 H 3.55 N 6.16 S 14.11
found: C 37.12 H 3.46 N 6.06 S 13.93.

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