Synthesis of Trimethyl α-Keto Trithioorthoesters and Dimethyl α-Keto Dithioacetals by Reaction of Esters with Tris(methylthio)methyllithium

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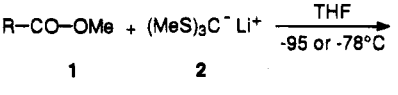
A complete study has been made of the reaction of tris(methylthio)methyllithium with aromatic, heteroaromatic, and aliphatic esters. It is a one-pot reaction that despite its complexity, and depending on the reagent ratios, the reaction conditions, and the possible use of additional reagents (*N*-(methylthio)phthalimide or BuLi), can supply easily, in excellent and reproducible yields, the trimethyl α-keto trithioorthoesters **3** or, alternatively, the dimethyl α-keto dithioacetals **4**. The reaction mechanism has been elucidated.

Although the basis of the chemistry of carboxyl sulfur-containing anion equivalents was laid down several decades ago,[1,2] some of their important potential synthetic applications have, until now, remained unexplored. In a recent revisitation of this matter from the point of view of synthetic uses for the tris(methylthio)methyl anion (its precursor, tris(methylthio)methane, is now easily available),[3] we carried out a systematic study of the nucleophilic substitution reaction of tris(methylthio)methyllithium with aliphatic halides.[3]

As a further development of possible synthetic applications of the tris(methylthio)methyl anion, our first goal was to synthesize the trimethyl α-keto trithioorthoesters **3** through reactions of tris(methylthio)methyllithium (**2**) with aromatic, heteroaromatic and aliphatic esters **1**. Compounds **3** have, on occasion, been indicated as synthesis intermediates[4–7] but until now no general method for their preparation has been proposed. In the course of this research a second objective, the synthesis of dimethyl α-keto dithioacetals **4**, was also reached (Scheme 1).

The literature dealing with reactions of esters with carboxyl sulfur-containing anion equivalents concerns only specific cases. In the closest fitting cases[5] the investigated reactions were between tris(phenylthio)-methyl, tris(*p*-tolylthio)methyl and tris(ethylthio)methyl anions with a mandelic acid derivative, methyl (4-methoxyphenyl)[(trimethylsilyl)oxy]acetate. Whereas the tests with the tris(arylthio)methyl anions gave no positive result, reactions involving the ester with the less sterically overcrowded tris(ethylthio)methyl anion, in molar ratios of 1:1 and for a reaction time of 30 min, resulted in the expected 1,1,1-tris(ethylthio)-3-(4-methoxyphenyl)-3-[(trimethylsilyl)oxy]propan-2-one and 1,1-bis(ethylthio)-3-(4-methoxyphenyl)-3-[(trimethylsilyl)oxy]propan-2-one in variable ratios, the trithioorthoester prevailing at relatively low temperature (−78 °C) and the dithioacetal at relatively high temperature (−40 °C). In these reactions the formation of dithioacetal was attributed to a generic thermal lability of the tris(ethylthio)methyl anion.

Scheme 1



1, 3, 4	R	1, 3, 4	R	1, 3, 4	R
a	Ph	**g**	2-Pyrrolyl	**m**	$MeOCH_2$
b	4-ClC_6H_4	**h**	N-$PhSO_2$-2-pyrrolyl	**n**	$(MeO)_2CH$
c	2,5-$Cl_2C_6H_3$	**i**	3-Pyridyl	**o**	*t*-Bu
d	4-$MeOC_6H_4$	**j**	H	**p**	MeOCO
e	2-Furyl	**k**	*n*-C_8H_{19}		
f	2-Thienyl	**l**	FCH_2		

Results and Discussion

Starting with this experimental data, we reacted, for 30 min and at different temperatures (-45, −78, −95 °C), a 1:1 molar ratio of the methyl benzoate (**1a**) and **2** in THF (Table 1, entries 1–3). This resulted in the trithioorthoester **3a** as well as the corresponding dithioacetal **4a**, the product yield varying significantly, but not dramatically, with the temperature changes (**3a**: 32–44%; **4a**: 34–19%). None of the reactions reached completion, as shown by the recovery of the starting compound **1a** (29–34%). Also, always isolated was tetrakis(methylthio)methane (**7**), in much the same equimolar amount as the dithioacetal **4a**.

Further tests were made to clarify the reaction with regard to formation of **4a** and **7**. Thus, **1a** and **2** were reacted in THF for 30 min at a constant temperature (−78 °C) but at different reagent molar ratios (**1a**:**2** = 1:1, 1:1.5, 1:2.2). Increasing the amount of **2** with respect to **1a** resulted in decreasing amounts of **3a** and increasing

[⊗] Abstract published in *Advance ACS Abstracts,* August 15, 1995.

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(2) Seebach, D. *Angew. Chem., Int. Ed. Engl.* **1967**, *6*, 442.

(3) Barbero, M.; Cadamuro, S.; Degani, I.; Dughera, S.; Fochi, R. *J. Chem. Soc., Perkin Trans. 1* **1993**, 2075.

(4) Russel, G. A.; Ochrymowycz, L. A. *J. Org. Chem.* **1969**, *34*, 3618.

(5) Matthews, B. R.; Jackson, W. R.; Jacobs, H. A.; Watson, K. G. *Aust. J. Chem.* **1990**, *43*, 1195.

(6) Trost, B. M.; Grese, T. A. *J. Am. Chem. Soc.* **1991**, *113*, 7363.

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Scheme 2

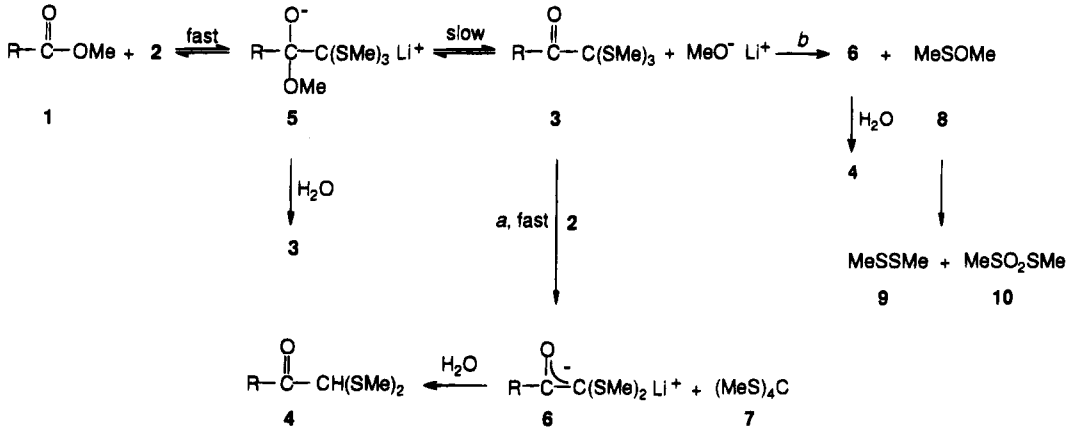


Table 1. Reactions of Methyl Benzoate (1a) with Tris(methylthio)methyllithium (2)

entry	molar ratio 1a:2	T (°C)	time (min)	yield[a] (mmol) 3a	4a	7	1a[b]
1	1:1	−45	30	3.22	3.44	2.80	2.94
2	1:1	−78	30	3.80	2.55	2.20	3.25
3	1:1	−95	30	4.39	1.89	1.80	3.38
4	1:1.5	−78	30	4.55	5.45	5.44	
5	1:2.2	−78	30		10	10	
6[c]	1:1	−95, 25	30, 1 h	3.99	2.36	1.83	2.94
7[c]	1:1	−95, 25	30, 8 h	2.17	4.44	1.80	2.90
8	1:1.25	−95	5	8.49	1.31	1.25	

[a] All the reactions were performed starting from 10 mmol of ester **1a**. Yields are of pure products isolated by column chromatography eluting with PE−CH_2Cl_2 (7:3, v/v). [b] The unreacted ester **1a** was not thoroughly recovered because no particular device was adopted for trapping it during evaporation of the solvent. [c] The byproducts dimethyl disulfide **9** and *S*-methyl methanethiosulfonate **10** were not isolated. Their presence in the reaction mixture was confirmed by GC−MS (Experimental Section).

amounts of **4a** (besides increasing amounts of **7**), a quantitative yield of **4a** being achieved at a **1a**:**2** molar ratio of 1:2.2 (Table 1, entries 2, 4, 5). These results show that the reaction proceeds through the formation of the trithioorthoester **3a** that by further reaction with **2** gives **7** and the stabilized enolate **6a**. The last, by protonation, gave rise to the dithioacetal **4a** (Scheme 2, path a; R = Ph).

Moreover, the reaction between **1a** and **2** in the 1:1 ratio, in THF, was carried out at a constant temperature of −95 °C for 30 min. The reaction mixture was allowed to warm to room temperature (about 25 °C) over 10 min and left for a further 1 h (entry 6) or 8 h (entry 7). Compared with the results in entry 3 there is a decrease in yield for **3a** and a corresponding increase in **4a**, while **7** remains constant. Moreover, among the reaction products dimethyl disulfide (**9**) and *S*-methyl methanethiosulfonate (**10**) are formed. In connection with these last two reactions it can be supposed that at a higher temperature the lithium methoxide reacts with **3a**, giving rise to **6a** and methyl methanesulfenate (**8**), which, by disproportion,[8] leads to **9** and **10** (Scheme 2, path b; R = Ph).

Direct evidence for the reversibility of both steps of the acyl nucleophilic substitution (Scheme 2) was obtained by adding **3a** to a solution of lithium methoxide in THF at −78 °C under nitrogen and then rapidly (5 min) raising the temperature to 8−10 °C. GC−MS analysis of samples taken successively and quenched in water revealed first the transformation of **3a** to methyl benzoate (**1a**) and tris(methylthio)methane and then the gradual disappearance of the latter due to the thermal decomposition of the precursor tris(methylthio)methyl anion, together with the concurrent formation of tetrakis(methylthio)ethylene.[3,9]

Finally, to maximize the yield of **3a** we varied the reagent ratios and optimized the reaction conditions. In the most favorable conditions, *i.e.*, a reagent ratio of 1:1.25 and 5 min reaction at −95 °C (entry 8), prevailing amounts of the expected trithioorthoester **3a** were isolated, together with a minor amount of the dithioacetal **4a**; the starting ester **1a** was totally absent.

Thus, from the synthetic point of view it was demonstrated that by choosing the appropriate reagent ratios and working conditions the reaction between **1a** and **2** can be largely directed toward the trithioorthoester **3a** (entry 8) or, alternatively, toward the dithioacetal **4a** (entry 5).

To verify the possibility of generalizing these procedures investigations were made into numerous other reactions between **2** and various aromatic, heteroaromatic, and aliphatic esters (Table 2, procedure A). When the same reagent ratios and the same reaction conditions established in entry 8 are maintained and methyl 4-chlorobenzoate (**1b**) and methyl 2,5-dichlorobenzoate (**1c**) (entries 11, 15) are used as the starting materials, the values of ratios **3b**:**4b** and **3c**:**4c** are greater than **3a**:**4a**. On the other hand, when methyl 4-methoxybenzoate **1d** (entry 18) is the starting material the ratio **3d**:**4d** is lower. These results can be interpreted assuming that: (i) the formation reaction of the trithioorthoesters **3** is slower than the following formation reaction of the enolates **6** (Scheme 2, path a); (ii) electron-withdrawing groups on the phenyl (*i.e.*, 4-chloro and 2,5-dichloro) favor the first step of the acyl nucleophilic substitution (formation of the tetrahedral intermediate **5**) but disfavor the second step (elimination of the methoxide ion with formation of **3**) and, consequently, disfavor the formation of the enolate **6**, this depending on the preliminary formation of **3**; and (iii) electron-releasing groups (*i.e.*, 4-methoxy) operating in the opposite direction favor the formation of the enolate **6**.

In general, this interpretation can also explain the other results in Table 2, procedure A. Let us consider the esters of the heteroaromatic pentaatomic systems:

(8) Koch P.; Ciuffarin, E.; Fava, A. *J. Am. Chem. Soc.* **1970**, *92*, 5971 and references cited therein.

(9) Seebach, D.; Geiss, K. H.; Beck, A. K.; Graf, B.; Daum, H. *Chem. Ber.* **1972**, *105*, 3280.

Table 2. Preparation of Trimethyl α-Keto Trithioorthoesters 3 and Dimethyl α-Keto Dithioacetals 4

			yield[b] (%)					
			proc A		proc B		proc C	proc D
entry	R	chromatographic solvent[a]	3	4	3	4	3	4
8	Ph	PE–CH_2Cl_2 (7:3)	85	13				
5						100		
9							97	
10								96
11	4-ClC_6H_4	PE–CH_2Cl_2 (7:3)	90	10				
12						96[c]		
13							97	
14								97
15	2,5-$Cl_2C_6H_3$	PE–CH_2Cl_2 (7:3)	97	3				
16						100[c]		
17								96
18[d]	4-$MeOC_6H_4$	PE–Et_2O (4:1)	50	27				
19						96[c]		
20							100[e]	
21	2-furyl	PE–MeCOMe (8.5:1.5)	81	19				
22						97		
23							97	
24								95
25[f]	2-thienyl	PE–CH_2Cl_2 (1:1)	46	35				
26						95[c]		
27							96[e]	
28	2-pyrrolyl		*g*					
29	2-pyrrolyl *N*-SO_2Ph	PE–MeCOMe (8.5:1.5)		tr[h]				
30						82[i]		
31							82[j]	
32	3-pyridyl	PE–Et_2O (1:1)	91	tr[h]				
33						95[c]		
34								88
35	H	PE–CH_2Cl_2 (4:1)	90					
36					93[k]	*l*		
37								*m*
38	*n*-C_9H_{19}	PE–CH_2Cl_2 (7:3)		42[n]				
39						88		
40							90[e]	
41	FCH_2	PE–MeCOMe (9.5:0.5)	87					
42					84[k,o]			
43								
44	$MeOCH_2$	PE–*t*-BuOH (9:1)	78	14				
45					tr[h]	90		
46							91	
47	$(MeO)_2CH$	PE–MeCOMe (9:1)	68	15				
48					tr[h]	81[c]		
49							82	
50	*t*-Bu	PE–MeCOMe (9.8:0.2)	*p*					
51						30[q]		
52							*p*	
53	MeOCO	PE–MeCOMe (8.5:1.5)	55[r]					
54					53[k,r]	*l*		

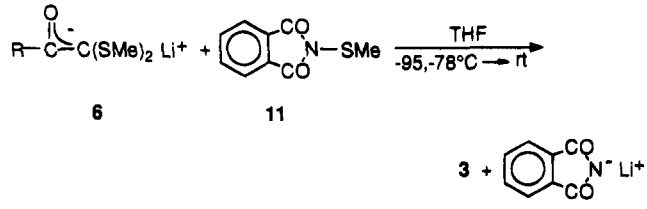
[a] PE = petroleum ether (40–70 °C). [b] Yields of pure isolated products. [c] The reagents' molar ratio was the following: 1:$(MeS)_3CH$:BuLi = 1:2.5:2.75. [d] 14% of unreacted **1d** was recovered. [e] Procedure C was modified as described in the Experimental Section. [f] 14% of unreacted **1f** was recovered. [g] The reaction also failed using an excess of **2** (30 mmol for 10 mmol of **1g**) and extending the reaction time to 3h at −45 °C. [h] Traces. [i] Reaction carried out at −45 °C for 30 min with the following reagents' molar ratio: **1h**:$(MeS)_3CH$:BuLi = 1:3:3.3. [j] 12 mmol of **11** was added to the reaction mixture obtained as described in footnote *i* starting from 10 mmol of **1h**. [k] Unchanged also extending the reaction time to 3h. [l] For the preparation of dithioacetals **4j**, **p**, see the Experimental Section. [m] By column chromatography of the crude residue with PE–CH_2Cl_2 (3:2), the only product isolated was 1,1,1-tris(methylthio)hexan-2-ol: 61% yield; bp 150 °C/1.3 mmHg (lit.[24] bp 171–173 °C/14 mmHg); ^1H NMR and IR identical to those reported.[24] [n] 53% of unreacted **1k** was recovered. [o] When the reaction mixture was quenched with D_2O, 1,1,1-tris(methylthio)-3-deuterio-3-fluoropropan-2-one and **3l** were obtained; the first was the major product. [p] The reaction failed. [q] The yield was also unchanged carrying out the reaction at −45 °C for 3 h. [r] The reaction mixture was quenched with a cold saturated aqueous NaCl solution (50 mL), and compound **3p** was repeatedly extracted with diethyl ether.

methyl 2-furoate (**1e**) led to a ratio **3e**:**4e** greater than **3f**:**4f** obtained with methyl 2-thenoate (**1f**) (entries 21,-25), in accordance with the greater 2-furyl electron-withdrawing effect (compared with 2-thienyl).[10] The reaction between **2** and methyl pyrrole-2-carboxylate (**1g**) failed (entry 28). In this particular case a preliminary deprotonation to the nitrogen leads to the pyrrolyl N-anion that, as a strong electron donor, inhibits the first step of the nucleophilic substitution. Instead the reaction took place with methyl *N*-(phenylsulfonyl)pyrrole-2-carboxylate (**1h**). In this case the 2-(*N*-phenylsulfonyl)-pyrrolyl, behaving as an electron donor (though not as strong as the above mentioned), gave, exclusively, the corresponding dithioacetal **4h** (entry 30). On the contrary, due to the strong electron-withdrawing effect of 3-pyridyl, methyl nicotinate (**1i**) gave, exclusively, the trithioorthoester **3i** (entry 32). Also in this case the reversibility of the acyl nucleophilic substitution was proved (see Experimental Section).

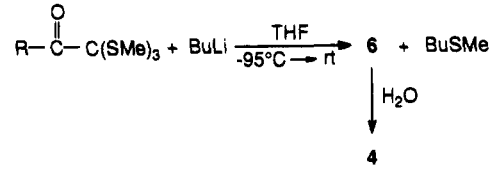
As far as the reaction of tris(methylthio)methyllithium with aliphatic esters is concerned it was observed that

(10) Fringuelli, F.; Taticchi, A. *J. Heterocycl. Chem.* **1973**, 89.

Scheme 3



Scheme 4



the reaction of methyl formate (**1j**) with **2** always stops, independently of the reagent ratios and reaction time, with the formation of the α-keto trithioorthoester **3j** (entries 35, 36). Separate reactions, where **3j** was reacted with **2** at −78 °C in the absence of lithium methoxide, gave rise to **4j** and **7** immediately. Instead, in the presence of lithium methoxide, still at −78 °C, the same reaction did not take place. These results can be interpreted by assuming that at −78 °C (or lower) the equilibrium between the intermediate **5j** and the trithioorthoester **3j** is completely displaced to the left. Also in this case certain evidence of the reversibility of the acyl nucleophilic substitution and route *b* of Scheme 2 (R = H) was obtained (see Experimental Section).

In the reaction of the methyl decanoate (**1k**) the electron-releasing effect of the alkyl disfavors the formation of **5k** and favors its conversion to **3k** causing the reaction to proceed fully toward the enolate **6k** (entry 38). Nevertheless, the presence of electron-withdrawing substituents on the alkyl (fluoro, methoxy) restores the possibility of obtaining, exclusively or prevailingly, the α-keto trithioorthoesters **3** (entries 41, 44, and 47).

Finally, the reaction of dimethyl oxalate (**1p**) with **2**, even in large excess, stopped at monosubstitution (entries 53 and 54) and resulted in the trithioorthoester **3p** exclusively. As in the case of the methyl formate it can be hypothesized that the equilibrium between the tetrahedral intermediate **5p** and the product **3p** (Scheme 2; R = MeOCO) is fully displaced to the left.

The reaction between **2** and esters suffers drastically from steric effects. In fact, the reaction with the methyl pivalate (**1o**) took place with difficulty (entries 50 and 51); however, it proceeded to the dithioacetal **4o** due to the electron-releasing effect of the alkyl.

With the objective of obtaining trithioorthoesters **3** and of maximizing the yield, the reaction mixture, containing exclusively or in relevant amounts the precursors of the dithioacetals **4**, *i.e.*, the enolates **6**, were added directly with *N*-(methylthio)phthalimide (**11**), as shown in Scheme 3 (Table 2; procedure C, entries 9, 13, 20, 23, 27, 31, 40, 46, and 49). This simple procedure raised the yield of **3** to, on the average, higher than 90%. The methylsulfenylation of the enolates **6a,k,m** was also realized in good yield using methanesulfenyl chloride (procedure E).

To reach the second goal, and therefore obtain the dithioacetals **4**, the esters **1** were reacted at a higher temperature (−78 °C) with at least twice the molar amounts of **2**, prolonging the reaction time to 15−30 min (procedure B). Yields of **4** were very high (entries 5, 12, 16, 19, 22, 26, 30, 33, 39, 45, 48, and 51). In the cases indicated in entries 10, 14, 17, 24, and 34 (procedure D) the same goal was reached by directly adding BuLi to the reaction mixture containing exclusively, or in relevant amounts, the trithioorthoesters **3** (Scheme 4).

In other proofs the dithioacetals **4a−d,j,k** were also obtained by reacting the trithioorthoesters **3a−d,j,k** at −78 °C with equimolar amounts of **2**. Under these conditions the formation of **4** was immediate. On the contrary, the reaction between **3a** and **2** in the presence of lithium methoxide needed about 30 min to reach completion. These last reactions prove what was previously noted, that (i) reactions of **3** to **4** are faster than reactions of **1** to **3**, (ii) the intermediates **5** and the trithioorthoesters **3** are in equilibrium, and (iii) the position of the equilibrium, depending on the nature of the radical, determines the result of the overall reaction.

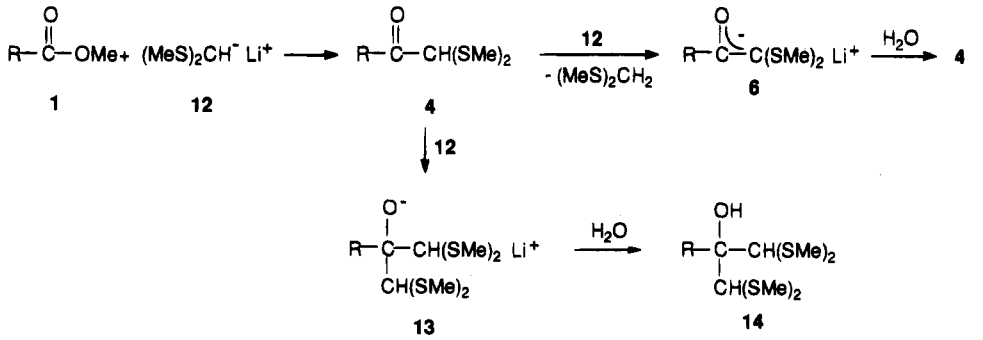
In the course of this work the dithioacetals **4a,j,k,p** were also obtained by reaction of **1a,j,k,p** with double the molar amounts of bis(methylthio)methyllithium (**12**; Scheme 5), in conditions similar to those used for the synthesis of diaryl α-keto dithioacetals.[11] Furthermore, it should be noted that the use of **2** (instead of **12**) for the synthesis of the dithioacetals **4**, starting from esters, can present advantages in that the bulky tris(methylthio)methyl anion does not lead to any subsequent attack at the carbonyl group with formation of the tertiary alcohol. Instead, there is some uncertainty in the use of the bis(methylthio)methyl anion. In fact, carrying out the reactions among the esters **1a,j,k** and **12** at −78 °C, or at higher temperature, led to the formation of byproducts, the tertiary alcohols **14a,j,k**. By working at −95 °C this synthetic complication for the esters **1a,k** was avoided, but only partially avoided for the ester **1j**.

Keeping in mind that tetrakis(methylthio)methane (**7**) treated with BuLi produces tris(methylthio)methyllithium (**2**),[2] in the present work an evaluation was also made of the possibility of utilizing **7** (easily available as it is the main byproduct of the above reactions) in place of tris(methylthio)methane. Thus, we reacted the esters **1a,k** with **7** that had been preliminarily treated with BuLi in THF at −95 °C (Scheme 6). The results were practically identical to those obtained from the same esters with **2** prepared from tris(methylthio)methane; in fact, depending on the reagent ratios and the reaction temperature, either **3a** or **4a** prevailed or **4k** was formed exclusively. The reactions for the formation of the dithioacetals **4** show an unusual feature. In fact, for such reactions to reach completion 2 mol of **7** (corresponding to two anion moles) are required for each mole of ester; however, 1 mol of **7** is restored. Thus, in effect, only 1 mol of **7** is actually used.

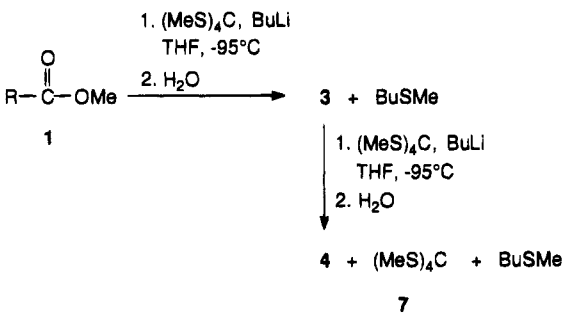
In conclusion, the one-pot reaction of the esters **1** with the tris(methylthio)methyllithium (**2**), depending on the reagent ratios, the reaction conditions, and the possible use of additional reagents (*N*-(methylthio)phthalimide or BuLi), can supply easily, and in excellent and reproducible yields, the trimethyl α-keto trithioorthoesters **3** or, alternatively, the dimethyl α-keto dithioacetals **4**. It is noteworthy that **3** have, for the first time, been obtained through a general procedure of wide applicability. Among the obtained products, of particular interest are the trithioorthoesters **3j,n,p** and the dithioacetals **4j,n,p** as potential synthons containing two or three functionalized carbon atoms.

(11) Guanti, G.; Banfi, L.; Guaragna, A.; Narisano, E. *J. Chem. Soc., Perkin Trans. 1* **1988**, 2369.

Scheme 5



Scheme 6



Advanced studies involving reactions between tris(methylthio)methyllithium, and other similar reagents, with various derivatives of carboxylic acids are in progress as a development of the present work.

Experimental Section

^{1}H NMR and IR spectra were recorded for solutions in CCl_4. Column chromatography was performed on Merck silica gel 60 (70–230 mesh ASTM). Petroleum ether refers to the fraction boiling in the range 40–70 °C and is abbreviated as PE. All the reactions were performed in oven-dried glassware under an atmosphere of nitrogen. Butyllithium (2.5 M solution in hexane), anhydrous THF, and bis(methylthio)methane were purchased from Aldrich. Tris(methylthio)methane,[3] *N*-(methylthio)phthalimide (**11**),[12] methanesulfenyl chloride,[13] and methyl pyrrole-2-carboxylate[14] (**1g**) were prepared following literature procedures. Chromatographic solvents and yields of the products are listed in Table 2.

Methyl *N*-(Phenylsulfonyl)pyrrole-2-carboxylate (1h). According to the procedure previously reported for the synthesis of 1-(phenylsulfonyl)pyrrole,[15] a solution of phenylsulfonyl chloride (6.18 g, 35 mmol) in CH_2Cl_2 (10 mL) was added dropwise at rt (20–25 °C), during 10 min, to a vigorously stirred mixture of methyl pyrrole-2-carboxylate (**1g**; 2.50 g, 20 mmol), tetrabutylammonium hydrogen sulfate (0.68 g, 2 mmol), 50% aqueous NaOH (10 mL, 180 mmol), and CH_2Cl_2 (100 mL). The reaction was complete after 30 min. The crude residue obtained after the usual workup was column chromatographed using PE–acetone (8.5:1.5) as eluent. The pure title compound was obtained in 92% yield (4.90 g): mp 94–95 °C (CCl_4–pentane) (lit.[16] mp 95–95.5 °C); ^{1}H NMR identical to that reported.

Trimethyl α-Keto Trithioorthoesters 3: Representative Procedures. 2,2,2-Tris(methylthio)-1-phenylethanone (3a). Procedure A. In entry 8 (Tables 1 and 2) a solution of tris(methylthio)methane (1.93 g, 12.5 mmol) in anhydrous THF (10 mL) was cooled to −95 °C under N_2. A 2.5 M solution in hexane of BuLi (5.5 mL, 13.75 mmol) was added dropwise during 5 min, and the resulting mixture was stirred at the same temperature for an additional 2 h. A white suspension of **2** was obtained. A solution of methyl benzoate (**1a**; 1.36 g, 10 mmol) in anhydrous THF (5 mL) was added dropwise during 5 min. After the addition was complete, the precipitate dissolved and a clear solution was obtained. After being stirred at −95 °C for a further 5 min, the resulting solution was directly quenched with diethyl ether–water (200 mL, 1:1). The aqueous layer was separated and extracted again with diethyl ether (80 mL). The combined organic extracts were washed with water (3 × 50 mL), dried over Na_2SO_4, and evaporated under reduced pressure. The crude residue was column chromatographed with PE–CH_2Cl_2 (7:3, v/v) as eluent. The first eluted product was tetrakis(methylthio)methane (**7**; 0.25 g, 1.25 mmol): mp 64–65 °C (PE) (lit.[3,9] mp 65–66 °C); MS *m/z* 153 (M^+ - SMe). The second eluted product was the title compound **3a** (2.19 g, 85%): mp 35 °C (PE) (lit.[4] bp 129–130 °C/0.05 mmHg); ^{1}H NMR identical to that reported;[4] IR 1668 cm^{-1} (CO). The third eluted product was 2,2-bis(methylthio)-1-phenylethanone (**4a**) (0.28 g, 1.31 mmol, 13%): mp 68–69 °C (CCl_4–PE) (lit.[4,17] mp 69 °C); ^{1}H NMR identical to that reported;[17] IR 1682 cm^{-1} (CO).

Procedure C. In entry 9 (Table 2) the reaction mixture prepared as described in procedure A was stirred at −95 °C under N_2 for 5 min. GC analysis of the resulting solution showed a mixture of **3a** and **4a** in an 8.5:1.5 ratio. A solution of *N*-(methylthio)phthalimide (**11**; 0.43 g, 2.25 mmol) in anhydrous THF (10 mL) was added. Then the cooling bath was removed and the reaction mixture was allowed to warm to rt. Stirring was continued for a further 1 h until disappearance of **4a** (GC analysis). After the above workup, the crude residue was chromatographed on a short column with PE–CH_2Cl_2 (7:3) as eluent to afford **7** (0.24 g, 1.20 mmol) and the title compound **3a** (2.51 g, 97%).

Entries 13, 23, 46, and 49 were also performed according to procedure C; the molar ratio **11**:**4b,e,m,n** was always 1.5:1.

Procedure E. A solution of methanesulfenyl chloride (0.19 g, 2.25 mmol) in anhydrous THF (5 mL) was added to the reaction mixture obtained as described above in procedure C. Then the cooling bath was removed, and the reaction mixture was allowed to warm to room temperature. Stirring was continued for a further 1 h until disappearance of **4a** (GC analysis). After the above workup, two products were isolated: **7** (0.22 g, 1.10 mmol) and the title compound **3a** (2.45 g, 95%).

According to procedure E trithioorthoesters **3k,m** were also obtained in 81 and 91% yields, respectively; the molar ratio methanesulfenyl chloride:**4k,m** was always 1.5:1.

2,2,2-Tris(methylthio)-1-(4-methoxyphenyl)ethanone (3d). Procedure C was modified as follows: in entry 20 (Table 2) the reaction mixture prepared as described in procedure A starting from methyl 4-methoxybenzoate (**1d**; 1.66 g, 10 mmol), tris(methylthio)methane (3.85 g, 25 mmol) and BuLi (11.0 mL, 27.5 mmol) in anhydrous THF (20 mL) was stirred at −78 °C under N_2 for about 30 min. GC analysis of the resulting

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solution showed the disappearance of **1d** and **3d** and the presence of **4d** and **7** as the only products. A solution of *N*-(methylthio)phthalimide (**11**; 2.90 g, 15 mmol) in anhydrous THF (30 mL) was added, and the reaction mixture was allowed to warm to rt (20–25 °C). Stirring was continued for a further 1 h until disappearance of **4d**. After workup identical to that described above, the crude residue was chromatographed on a short column with PE–diethyl ether (4:1) as eluent to afford **7** (2.00 g, 10 mmol) and the title compound **3d** (2.88 g, 10 mmol, 100%): mp 57–58 °C (PE); MS *m/z* 241 (M^+ – SMe); ^{1}H NMR identical to that reported[18] (mp and yield are not reported); IR 1660 cm^{-1} (CO).

Also, entries 27 and 40 were carried out according to procedure C modified as above. In fact, in these cases the use of an excess of **2** makes it possible for less reactive esters to react fully.

Physical properties of the new α-keto trithioorthoesters **3** are as follows:

3b: mp 53–54 °C (pentane); MS *m/z* 245 (M^+ – SMe); ^{1}H NMR identical to that reported[18] (mp and yield are not reported); IR 1667 cm^{-1} (CO).

3c: mp 68–69 °C (pentane); MS *m/z* 280 (M^+ – SMe); ^{1}H NMR 2.12 (s, 9H), 7.12–7.23 and 7.83–7.93 (2 m, 2:1, 3H); IR 1702 cm^{-1} (CO).

3e: mp 70–71 °C (CH_2Cl_2–pentane); MS *m/z* 201 (M^+ – SMe); ^{1}H NMR 2.00 (s, 9H), 6.36 (dd, 1H, $J_{3,4}$ = 4.00, $J_{4,5}$ = 2.00), 7.43–7.50 (m, 1H), 7.70 (d, 1H, $J_{3,4}$ = 4.00); IR 1662 cm^{-1} (CO).

3f: mp 48–49 °C (pentane); MS *m/z* 217 (M^+ – SMe); ^{1}H NMR 2.10 (s, 9H), 7.13 (t, 1H, $J_{3,4} = J_{4,5}$ = 5.00), 7.65 (d, 1H, $J_{3,4}$ = 5.00), 8.46 (dd, 1H, $J_{3,5}$ = 1.00, $J_{4,5}$ = 5.00); IR 1647 cm^{-1} (CO).

3g:[19] mp 114 °C (CCl_4–pentane); MS *m/z* 247 (M^+); ^{1}H NMR (80 MHz, $CDCl_3$) 2.07 (s, 9H), 6.27 (ddd, 1H, $J_{1,4} = J_{4,5}$ = 2.50, $J_{3,4}$ = 5.00), 6.99 (ddd, 1H, $J_{1,3}$ = 3.00, $J_{3,4}$ = 5.00, $J_{3,5}$ = 1.50), 7.64 (ddd, 1H, $J_{1,5}$ = 3.50, $J_{3,5}$ = 1.50, $J_{4,5}$ = 2.50), 9.90 (br s, 1H); IR 1627 cm^{-1} (CO).

3h: mp 124 °C (CCl_4); MS *m/z* 340 (M^+ – SMe); ^{1}H NMR 2.02 (s, 9H), 6.27 (t, 1H, *J* = 3.00), 7.47–7.77 (m, 4H), 7.83–8.15 (m, 3H); IR 1661 cm^{-1} (CO).

3i: mp 40–41 °C (pentane); MS *m/z* 212 (M^+ – SMe); ^{1}H NMR 1.97 (s, 9H), 7.08 (dd, 1H, $J_{4,5}$ = 7.00, $J_{5,6}$ = 5.00), 8.35–8.58 (m, 2H), 9.15–9.27 (m, 1H); IR 1671 cm^{-1} (CO).

3j: bp 88–90 °C/1 mmHg (lit.[20] bp 74–75 °C/0.5 mmHg); ^{1}H NMR and IR identical to those reported.[20]

3k: bp 158 °C/0.5 mmHg; MS *m/z* 261 (M^+ – SMe); ^{1}H NMR 0.70–1.00 (m, 3H), 1.00–1.50 (m, 14H), 1.96 (s, 9H), 2.85 (t, 2H, *J* = 7.00); IR 1702 cm–1 (CO).

3l: mp 46–47 °C (CH_2Cl_2–pentane); MS *m/z* 167 (M^+ – SMe); ^{1}H NMR 2.00 (s, 9H), 5.27 (d, 2H, $J_{H,F}$ = 46); IR 1726 cm^{-1} (CO).

3m: mp 28 °C ($CHCl_3$–pentane); MS *m/z* 179 (M^+ – SMe); ^{1}H NMR 2.00 (s, 9H), 3.30 (s, 3H), 4.47 (s, 2H); IR 1717 cm^{-1} (CO).

3n: mp 47–48 °C (pentane); MS *m/z* 225 (M^+ – OMe); ^{1}H NMR 1.95 (s, 9H), 3.30 (s, 6H), 5.38 (s, 1H); IR 1716 cm^{-1} (CO).

3p: mp 37–38 °C (pentane); MS *m/z* 193 (M^+ – SMe); ^{1}H NMR 2.03 (s, 9H), 3.77 (s, 3H); IR 1702, 1745 cm^{-1} (2 CO).

Dimethyl α-Keto Dithioacetals 4: Representative Procedures. 2,2-Bis(methylthio)-1-phenylethanone (4a). Procedure B. In entry 5 (Tables 1 and 2) the reaction mixture prepared as described in procedure A starting from methyl benzoate (**1a**; 1.36 g, 10 mmol), tris(methylthio)methane (3.39 g, 22 mmol), and BuLi (9.7 mL, 24.2 mmol) in anhydrous THF (20 mL) was stirred at −78 °C under N_2. Progress of the reaction was monitored by GC, and stirring at −78 °C was continued until disappearance of the intermediate **3a** (about 30 min). After workup identical to that described above, the crude residue was chromatographed on a short column with PE–CH_2Cl_2 (7:3) as eluent to afford **7** (2.00 g, 10 mmol) and the title compound **4a** (2.12 g, 10 mmol; 100%).

Procedure D. In entry 10 (Table 2) the reaction mixture prepared as described in procedure A starting from methyl benzoate (**1a**; 1.36 g, 10 mmol), tris(methylthio)methane (1.93 g, 12.5 mmol), and BuLi (5.5 mL, 13.75 mmol) in anhydrous THF (10 mL) was stirred at −95 °C under N_2 for 5 min. A second portion of BuLi (3.70 mL, 9.35 mmol) was added dropwise to the resulting solution consisting of a mixture of **3a** and **4a** in an 8.5:1.5 ratio. Then the reaction mixture was allowed to warm gradually to rt (20–25 °C; about 30 min). GC analysis showed the disappearance of the intermediate **3a** and the presence of three products: butyl methyl sulfide, MS *m/z* 104 (M^+), **7**, and **4a**. The above workup afforded **7** (0.16 g, 0.8 mmol) and the title compound **4a** in 96% yield (2.06 g, 9.71 mmol).

Also, entries 14, 17, 24, and 34 (Table 2) were performed according to procedure D; the molar ratio BuLi:**4b,c,e,i** was always 1.1:1. Procedure D failed in the case of aliphatic esters.

Physical properties of the new α-keto dithioacetals are as follows:

4b: mp 56–57 °C (CCl_4–pentane); MS *m/z* 246 (M^+); ^{1}H NMR 2.09 (s, 6H), 5,15 (s, 1H), 7.40 (d, 2H, *J* = 9.00), 7.95 (d, 2H, *J* = 9.00); IR 1680 cm^{-1} (CO).

4c: mp 106 °C (CH_2Cl_2–pentane); MS *m/z* 282 (M^+ + 1); ^{1}H NMR 2.10 (s, 6H), 5.00 (s, 1H), 7.20–7.30 (m, 2H), 7.30–7.45 (m, 1H); IR 1701 cm^{-1} (CO).

4d: mp 61–62 °C (CH_2Cl_2–PE); MS *m/z* 242 (M^+); ^{1}H NMR 2.05 (s, 6H), 3.80 (s, 3H), 5.08 (s, 1H), 6.78 (d, 2H, *J* = 9.00), 7.85 (d, 2H, *J* = 9.00); IR 1673 cm^{-1} (CO).

4e: mp 129–130 °C (CCl_4–pentane); MS *m/z* 202 (M^+); ^{1}H NMR 2.05 (s, 6H), 4.92 (s, 1H), 6.40 (dd, 1H, $J_{3,4}$ = 3.40, $J_{4,5}$ = 2.00), 7.06 (d, 1H, $J_{3,4}$ = 3.40), 7.32–7.43 (m, 1H); IR 1675 cm^{-1} (CO).

4f: mp 118–119 °C (CCl_4); MS *m/z* 218 (M^+); ^{1}H NMR 2.10 (s, 6H), 4.85 (s, 1H), 7.00 (t, 1H, $J_{3,4} = J_{4,5}$ = 5.00), 7.49 (d, 1H, $J_{3,4}$ = 5.00), 7.77 (d, 1H, $J_{4,5}$ = 5.00); IR 1665 cm^{-1} (CO).

4g:[21] mp 85 °C (CCl_4–pentane); MS *m/z* 201 (M^+); ^{1}H NMR (80 MHz, $CDCl_3$) 2.17 (s, 6H), 5.02 (s, 1H), 6.35 (ddd, 1H, $J_{1,4} = J_{4,5}$ = 2.00, $J_{3,4}$ = 4.50), 7.00–7.21 (m, 2H), 9.60 (br s, 1H); IR 1640 cm^{-1} (CO).

4h: mp 119 °C (CCl_4–pentane); MS *m/z* 341 (M^+); ^{1}H NMR 2.02 (s, 6H), 4.75 (s, 1H), 6.21 (t, 1H, *J* = 3.00), 6.82–7.00 (m, 1H), 7.60–7.72 (m, 1H), 7.33–7.60 (m, 3H), 7.85–8.07 (m, 2H); IR 1668 cm^{-1} (CO).

4i: mp 49 °C (CCl_4–pentane); MS *m/z* 213 (M^+); ^{1}H NMR 2.03 (s, 6H), 5.00 (s, 1H), 7.15 (dd, 1H, $J_{4,5}$ = 8.00, $J_{5,6}$ = 4.50), 8.40–8.60 (m, 1H), 8.85–9.00 (m, 1H); IR 1685 cm^{-1} (CO).

4j: bp 60–62 °C/0.4 mmHg (lit.[22] bp not reported); ^{1}H NMR and IR identical to those reported.[22]

4k: mp 33–34 °C (PE); MS *m/z* 262 (M^+); ^{1}H NMR 0.75–1.00 (m, 3H), 1.05–1.37 (m, 14H), 2.00 (s, 6H), 2.55 (t, 2H, *J* = 8.00), 4.10 (s, 1H); IR 1712 cm^{-1} (CO).

4m: mp 31–32 °C ($CHCl_3$–pentane); MS *m/z* 180 (M^+); ^{1}H NMR 2.04 (s, 6H), 3.39 (s, 3H), 4.07 (s, 2H), 4.60 (s, 1H); IR 1719 cm^{-1} (CO).

4n: bp 109–110 °C/0.75 mmHg; MS *m/z* 210 (M^+); ^{1}H NMR 2.09 (s, 6H), 3.40 (s, 6H), 4.74 (s, 1H), 4.85 (s, 1H); IR 1729 cm^{-1} (CO).

4o: mp 48 °C (pentane) (lit.[23] mp 48–50 °C); MS *m/z* 192 (M^+); ^{1}H NMR 1.21 (s, 9H), 2.02 (s, 6H), 4.56 (s, 1H); IR 1702 cm^{-1} (CO).

4p: mp 35 °C (PE); MS *m/z* 194 (M^+); ^{1}H NMR 2.00 (s, 6H), 3.80 (s, 3H), 5.00 (s, 1H); IR 1726, 1737 cm^{-1} (2 CO).

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(19) Obtained by hydrolysis of **3h** with KOH (10% in 95% EtOH) in a molar ratio of 1:1, under conditions similar to those previously reported.[15] The reaction was complete after 1 h at 50 °C. Column chromatography with PE–acetone (4:1) as eluent afforded compound **3g** and tris(methylthio)methane in 52 and 40% yields, respectively.

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(21) Obtained in 46% yield by hydrolysis of **4h** with KOH (10% in 95% EtOH) in a molar ratio of 1:3, under the conditions reported in ref 19. Byproduct bis(methylthio)methane was isolated only in traces owing to its volatility.

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Reactions of Table 1. Entries 5 and 8 are described above. Entries 1–4 were also performed in the same way, varying the reagents' molar ratio and reaction temperature and time, as detailed in Table 1. In entries 6 and 7 the reaction mixture prepared as decribed in procedure A starting from methyl benzoate (**1a**, 1.36 g, 10 mmol), tris(methylthio)methane (1.54 g, 10 mmol), and BuLi (4.4 mL, 11 mmol) in anhydrous THF (10 mL) was stirred under N_2 at −95 °C for 30 min. GC–MS analysis of the colorless solution showed the presence of four compounds: unreacted ester **1a**, **7**, **4a**, and **3a**. Then the reaction mixture was allowed to warm to rt (20–25 °C) and left for a further 1 h (entry 6) or 8 h (entry 7). The solution changed from colorless to yellow, and GC–MS analysis showed the appearance of two new compounds, dimethyl disulfide **9**, MS m/z 94 (M^+), and *S*-methyl methanethiosulfonate **10**, MS m/z 126 (M^+). With time, **3a** decreased gradually and **4a**, **9**, and **10** increased correspondingly, but **7** and **1a** remained unchanged. Results are reported in Table 1.

Reaction of Tris(methylthio)methyllithium 2 with Trimethyl α-Keto Trithioorthoesters 3. Typical Procedure. Bis(methylthio)ethanal (4j). A solution of tris(methylthio)ethanal (**3j**; 0.91 g, 5 mmol) in anhydrous THF (5 mL) was added dropwise during 5 min to a suspension of **2**, prepared as described in procedure A starting from tris(methylthio)methane (0.77 g, 5 mmol) and BuLi (2.2 mL, 5.5 mmol) in anhydrous THF (5 mL), under stirring in a N_2 atmosphere and at −78 °C. After the addition was complete, GC analysis of the resulting colorless solution showed the complete disappearance of **3j** and the presence of **7** and **4j** as the only products. The reaction mixture was quenched with a cold saturated aqueous NaCl solution (50 mL) and repeatedly extracted with diethyl ether. The crude residue, obtained after the usual workup, was chromatographed on a short column, eluting with PE–CH_2Cl_2 (4:1), to afford **7** (0.90 g, 4.5 mmol) and **4j** (0.58 g, 4.3 mmol, 85%).

The reaction failed when it was carried out for 2 h at −78 °C in the presence of an equimolar amount of lithium methoxide, prepared from BuLi (2 mL, 5 mmol) and MeOH (0.16 g, 5 mmol). Only the starting compounds, tris(methylthio)methane and **3j**, were quantitatively recovered; no traces of **4j** were present.

Also **3a–d,k** reacted in the same way with **2**, and **4a–d,k** formed quantitatively at once. Instead there was a slow-down in the reaction of **3a** with **2** in presence of lithium methoxide. In this case, the complete conversion of **3a** in **4a** needed 30 min.

Reactions of Lithium Methoxide with Trimethyl α-Keto Trithioorthoesters 3. (1) A solution of tris(methylthio)ethanal (**3j**; 0.36 g, 2 mmol) in THF (3 mL) was added to a solution of lithium methoxide, prepared from BuLi (1 mL, 2.4 mmol) and MeOH (0.08 g, 2.4 mmol), in THF (3 mL), and maintained at −78 °C under stirring and under a N_2 atmosphere. After 30 min, GC analysis of a portion of the mixture quenched with water, the temperature being maintained at −78 °C, showed **3j** as only product. The cooling bath was removed, allowing the temperature to rise to 8–10 °C in a period of about 10 min. GC–MS analysis of a sample quenched with water, the temperature being maintained at 10 °C, showed the presence of four products: methyl formate (**1j**), tris(methylthio)methane (**3j**), and tetrakis(methylthio)ethylene. Subsequent analyses showed that **3j** decreased gradually until it disappeared after 2.5 h, and correspondingly **1j**, tris(methylthio)methane, and tetrakis(methylthio)ethylene increased. After the disappearance of **3j**, tris(methylthio)methane also decreased until it disappeared after 3.5 h. At this point, the only reaction products were **1j** (MS m/z 60, M^+; confirmed also by ^{1}H NMR and IR spectra) and tetrakis(methylthio)ethylene that was isolated by the usual workup (0.18 g, 86%): mp 62 °C (PE) (lit.[3,9] mp 62 °C).

(2) The reaction mixture prepared as described above was stirred at - 78 °C for 30 min. Then the cooling bath was removed, and the temperature was allowed to rise to 38 °C in a period of about 5 min and maintained for a further 10 min. GC–MS analysis of a sample quenched with water showed seven products: **1j**, MS m/z 60 (M^+), dimethyl disulfide **9**, MS m/z 94 (M^+), *S*-methyl methanethiosulfonate (**10**), MS m/z 126 (M^+), **4j**, tris(methylthio)methane, **3j**, and tetrakis(methylthio)ethylene. After 30 min at 38 °C, tris(methylthio)methane and **3j** disappeared. The crude residue obtained after the usual workup was column chromatographed, eluting with PE–CH_2Cl_2 (7:3), to afford tetrakis(methylthio)ethylene (0.12 g, 56%) and **4j** (0.12 g, 44%).

(3) According to the procedure described above, a mixture of 2,2,2-tris(methylthio)-1-phenylethanone (**3a**) (0.52 g, 2 mmol), BuLi (1 mL, 2.4 mmol), and MeOH (0.08 g, 2.4 mmol) in THF (6 mL) was stirred for 30 min at −78 °C under a N_2 atmosphere. The cooling bath was removed, and the temperature was allowed to rise to 8–10 °C and was maintained for 2 h. GC–MS analysis of a sample quenched with water, the temperature being maintained at 10 °C, showed the following compounds: **1a**, tris(methylthio)methane, **7**, tetrakis(methylthio)ethylene, **4a**, and **3a** as major products. Then the reaction temperature was allowed to rise to rt (20–25 °C). After 12 h, GC–MS analysis showed the appearance of two new compounds, **9** and **10**, and the disappearance of **3a** and tris(methylthio)methane. Among them, **4a** was the major product.

(4) According to the above procedure, a mixture of 2,2,2-tris(methylthio)-1-(3-pyridyl)ethanone (**3i**; 0.26 g, 1 mmol), BuLi (0.5 mL, 1.2 mmol), and MeOH (0.04 g, 1.2 mmol) in THF (5 mL) was stirred for 30 min at −78 °C under N_2. The cooling bath was removed, and the temperature was allowed to rise to 8–10 °C in a period of 5 min. A white precipitate of methyl nicotinate **1i** began to form. GC–MS analysis of a sample quenched with water showed the presence of **1i**, tris(methylthio)methane, tetrakis(methylthio)ethylene, and **3i** as major products. After 2.5 h the only products were **1i** and tetrakis(methylthio)ethylene, which were separated in 57% (0.08 g) and 76% yields (0.08 g), respectively, by column chromatography eluting with PE–diethyl ether (3:7).

Reaction of Esters 1 with Bis(methylthio)methyllithium (11). Typical Procedure: 2,2-Bis(methylthio)ethanal (4j). According to procedure B, a solution of bis(methylthio)methane (2.16 g, 20 mmol) in anhydrous THF (10 mL) was cooled to −95 °C under N_2. BuLi (8.8 mL, 22 mmol) was added dropwise during 5 min, and the resulting mixture was stirred for 2 h. A solution of methyl formate (**1j**; 0.60 g, 10 mmol) in anhydrous THF (5 mL) was added during 5 min, and stirring at −95 °C was continued for a further 5 min. Then the mixture was directly quenched with a cold saturated aqueous NaCl solution (50 mL) and repeatedly extracted with diethyl ether (4 × 50 mL). The crude residue obtained after the usual workup was chromatographed with PE–CH_2Cl_2 (4:1) as eluent. The first eluted product was the starting compound bis(methylthio)methane (isolated in variable amounts as no particular device was adopted for trapping it). The second eluted product was **4j** (1.06 g, 78%). The third eluted product was 1,1,3,3-tetrakis(methylthio)propan-2-ol (**14j**; 0.15 g, 6%): mp 57–58 °C (PE); MS m/z 244 (M^+); ^{1}H NMR (80 MHz, $CDCl_3$) 2.12 (s, 6H), 2.17 (s, 6H), 3.12 (br s, 1H), 3.88 (dd, 1H, J = 4.55, J = 5.90), 4.17 and 4.18 (2 d, 2H, J = 4.55, J = 5.90); IR 3480 cm^{-1} (OH). When the reaction was carried out at −78 °C, yields of **4j** and **14j** were 67 and 11%, respectively.

According to the above procedure, and working at −95 °C, esters **1a**, **1k**, and **1p** afforded dithioacetals **4a**, **4k**, and **4p** as the only products, in 96, 84, and 22% yields, respectively. When the reactions were carried out at −78 or −45 °C, **1a** afforded 78 or 68% of **4a** and 6 or 23% yields of **14a**, and **1k** afforded 68% of **4k** and 12% yields of **14k**.

1,1,3,3-Tetrakis(methylthio)-2-phenylpropan-2-ol (14a): mp 53 °C (PE); MS m/z 320 (M^+); ^{1}H NMR (80 MHz, $CDCl_3$) 1.74 and 1.95 (2 s, 1:1, 12 H), 3.70 (br s, 1H), 4.55 (s, 2H), 7.12–7.35 (m, 3H), 7.35–7.57 (m, 2H); IR 3478 cm^{-1} (OH).

1,1-Bis(methylthio)-2-[bis(methylthio)methyl]undecan-2-ol (14k): bp 192 °C/0.4 mmHg; MS m/z 370 (M^+); ^{1}H NMR (80 MHz, $CDCl_3$) 0.70–1.00 (m, 3H), 1.15–1.40 (m, 14H), 1.70–1.87 (m, 2H), 2.21 (s, 12H), 2.97 (br s, 1H), 4.23 (s, 2H); IR 3500 cm^{-1} (OH).

Reaction of Methyl Benzoate 1a with Tetrakis(methylthio)methane 7: Typical Procedures. (1) According to procedure A, a solution of tetrakis(methylthio)methane (**7**)

(2.50 g, 12.5 mmol) in anhydrous THF (10 mL) was cooled to −95 °C under N_2. BuLi (5.5 mL, 13.75 mmol) was added dropwise during 5 min, and the resulting mixture was stirred at the same temperature for an additional 2 h. A white suspension of **2** was obtained. A solution of methyl benzoate (**1a**; 1.36 g, 10 mmol) in anhydrous THF (5 mL) was added dropwise during 5 min. After being stirred at −95 °C for a further 5 min, the resulting solution was directly quenched with diethyl ether−water (200 mL, 1:1). GC−MS analysis of the crude residue obtained after the usual workup showed the presence of four products: butyl methyl sulfide, MS *m*/*z* 104 (M^+), **7**, **4a**, and **3a**. Chromatography with PE−CH_2Cl_2 (7:3) as eluent afforded the last two products in yields of 14% (0.30 g, 1.41 mmol) and 83% (2.15 g, 8.33 mmol), respectively; 0.28 g (1.40 mmol) of **7** was also recovered.

(2) According to procedure B, the reaction mixture prepared as described above starting from **1a** (1.36 g, 10 mmol), **7** (4.40 g, 22 mmol), and BuLi (9.7 mL, 24.2 mmol) in anhydrous THF (10 mL) was stirred at −78 °C under N_2. After 30 min the reaction was complete. GC−MS analysis of the crude residue obtained after the usual workup showed the presence of three products: butyl methyl sulfide, **7**, and **4a**. Chromatography on a short column with PE−CH_2Cl_2 (7:3) afforded **4a** in quantitative yield (2.12 g, 10 mmol); 1.98 g (9.9 mmol) of **7** was also recovered.

According to the above procedure, ester **1k** afforded dithioacetal **4k** in 89% yield (2.32 g, 8.90 mmol); the amount of recovered **7** was 1.76 g (8.8 mmol).

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Supporting Information Available: Elemental analyses (3 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

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