

Deprotonation of Aryl Methanedithioate by Lithium Amides: Formation of Lithium Arylthio(thioxo)methanide Having Unique Reactivity

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Deprotonation of aryl methanedithioate **5** bearing a bowl-type bulky substituent with lithium tetramethylpiperide at low temperature gave organolithium species **9** which was in equilibrium with a dimeric species **10**; **9** extruded C=S at higher temperatures, thus representing a new, convenient source of C=S.

Acyllithiums **1**¹ and carbamoyllithiums **2**² are important reagents in organic synthesis and their chemistry has been relatively well established. The corresponding sulfur analogues, however, have been much less studied. Seebach and his co-workers reported the formation of thiocarbamoyllithiums **3** by deprotonation of thioformamides with lithium diisopropylamide and their reactions with some electrophiles.³ The intermediacy of **4** (R = Mes*; Mes* = 2,4,6-tri-*t*-butylphenyl) was proposed by us in the reaction of Mes*Li with carbon disulfide (Chart 1).⁴ We now wish to describe a new and straightforward approach to lithium arylthio(thioxo)methanide **4** and its unique reactivity.

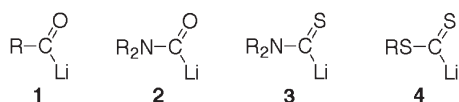
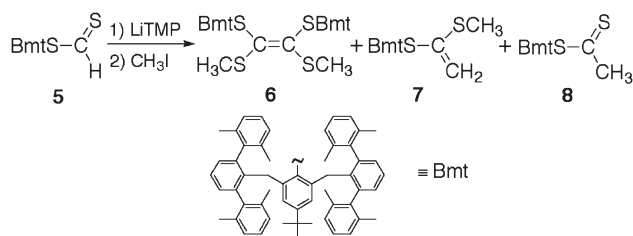


Chart 1.

Methanedithioate **5**⁵ bearing a bowl-type bulky substituent, 4-*t*-butyl-2,6-bis[(2,2'',6,6''-tetramethyl-*m*-terphenyl-2'-yl)-methyl]phenyl⁶ (denoted as Bmt hereafter) was allowed to react with lithium 2,2,6,6-tetramethylpiperide (LiTMP, 1.2 equiv.) in THF at -98 °C for 5 min and then to this solution was added methyl iodide (1.2 equiv.) at the same temperature. After quenching with aq ammonium chloride at -30 °C and chromatographic purification (gel permeation liquid chromatography and TLC), alkenes **6** and **7** were obtained in 79 and 20%, respectively (Scheme 1 and Table 1, Entry 1).⁷ The *cis*-configuration of **6** was established by X-ray crystallography. The use of 1.0 equiv. each of LiTMP and methyl iodide resulted in **6** (69%) and **8** (7%) (Entry 2), showing that **7** was formed via **8**.

The plausible mechanism for the formation of **6–8** is shown in Scheme 2. Alkene **6** is most likely produced by dimerization^{8,9}



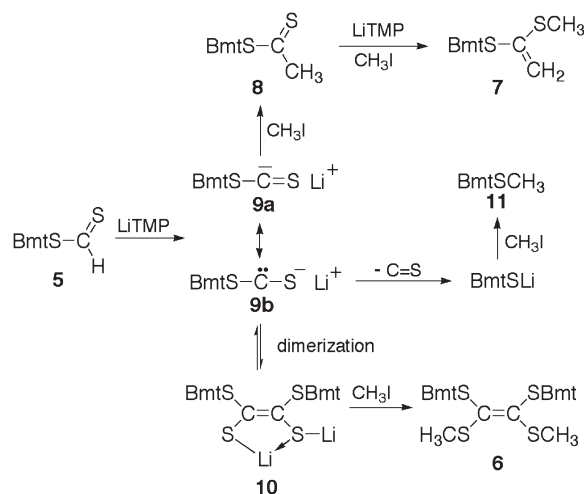
Scheme 1.

Table 1. Deprotonation of **5** with LiTMP followed by quenching with CH₃I^a

Entry	React. conditions ^b	CH ₃ I/equiv.	Yield/%			
			6	7	8	11
1	-98 °C, 5 min	1.2	79	20	—	—
2	-98 °C, 5 min ^c	1.0	69	—	7	—
3	-78 °C, 1 h	1.2	76	7	14	—
4	-50 °C, 1 h	1.2	33	—	—	41
5	-30 °C, 1 h	1.2	—	—	—	74

^aDeprotonation in all reactions was carried out at -98 °C.

^bThe reaction conditions indicate temperature and time before treatment with CH₃I. ^cThe starting material **5** was recovered in 7%.



Scheme 2.

of **9** with a carbene character as shown in a canonical structure **9b** giving a dimeric species **10**, followed by reaction with methyl iodide. The exclusive formation of *cis*-isomer **6** is considered to be due to the stabilization of **10** by chelation of a lithium cation with thiolate anions. Dithioate **8** is most likely formed by reaction of **9** bearing a carbanionic character **9a** with methyl iodide and then converted into **7** with excess LiTMP and methyl iodide.

Essentially the same results were obtained in Entry 3 where methyl iodide was added after the reaction solution was warmed to -78 °C and stirred for 1 h. Quenching with methyl iodide at -50 °C under otherwise similar conditions (Entry 4), however, led to the formation of sulfide **11** (41%) as a major product along with **6** (33%), indicating that the loss of carbon monosulfide (CS) from **9** took place partially at -50 °C (see Scheme 2). Compound **11** was a sole product (74%) in the reaction at -30 °C. These observations clearly show that dissociation of **10** to **9**

(a backward reaction of dimerization of **9** to **10**) occurs in the reaction solution. Compound **9** is unstable even around -50°C decomposing into CS and BmtSLi, the latter of which reacts with methyl iodide to afford **11**.

In order to confirm the formation of CS in the present reactions, morpholine (2 equiv.) was added to a solution of **9** generated at -78°C . The temperature of the reaction solution was raised stepwise to -30°C (-50°C , 30 min and -30°C , 30 min) and quenched with aq ammonium chloride at -30°C to give thioamide **12** (83%, Chart 2) besides thiol BmtSH (83%).

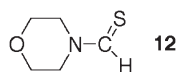
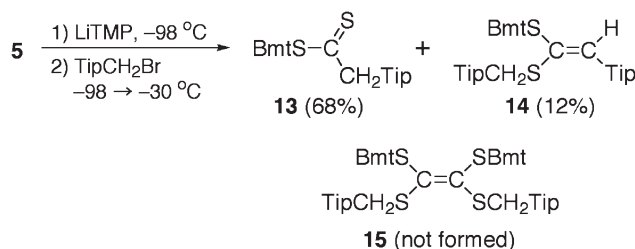


Chart 2.

Carbon monosulfide is a useful building block of thiocarbonyl compounds and known to be highly reactive¹⁰ although it is isoelectronic with carbon monoxide and isocyanides both of which are stable. The practical preparative method of CS so far known is decomposition of carbon disulfide vapor in a high-voltage ac discharge which requires special equipment.¹¹ Senning and Klabunde have reported the reaction of CS with amines among which morpholine gave thioamide **12** in the highest yield (49%).^{11b} In view of the experimental simplicity and the higher yield of the product **12** in our procedure, the deprotonation of dithioate **5** is a new and convenient method for the generation of CS in solution.

When the deprotonation of **5** was performed with LiTMP at -98°C , TipCH₂Br (Tip = 2,4,6-triisopropylphenyl) (1.2 equiv.) added at the same temperature, and then the reaction solution quenched with aq ammonium chloride after the temperature of the solution was raised to -30°C over 3 h, dithioate **13** (68%) and alkene **14** (12%) were obtained without any formation of tetrathiasubstituted alkene **15** unlike in the reaction with methyl iodide. As in the formation of **7** from **8**, **14** is considered to be produced from **13**. The obtention of **13** and **14** instead of **15** indicates that bulky TipCH₂Br cannot react with dianion **10** because of steric repulsion against Bmt group but reacts with more reactive **9** in equilibrium with **10** to give **13** (Scheme 3).



Scheme 3.

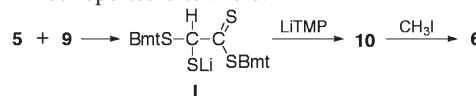
In conclusion, we have found that the deprotonation of methanedithioate **5** with LiTMP affords lithium species **9** which is in equilibrium with dimeric species **10** at low temperatures (-78 – -98°C) and extrudes CS at higher temperatures (-50 – -30°C). This reaction provides a new and convenient method for the generation of CS.

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References and Notes

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- 2 T. Mizuno, I. Nishiguchi, and T. Hirashima, *Tetrahedron*, **49**, 2403 (1993), and references cited therein.
- 3 D. Seebach, W. Lubosch, and D. Enders, *Chem. Ber.*, **109**, 1309 (1976).
- 4 R. Okazaki, T. Fujii, and N. Inamoto, *Chem. Commun.*, **1984**, 1010; R. Okazaki, T. Fujii, and N. Inamoto, *J. Phys. Org. Chem.*, **1**, 75 (1988).
- 5 Methanedithioate **5** was synthesized in 74% by the reaction of BmtLi, generated by lithiation of BmtBr with *t*-BuLi at -78°C , with carbon disulfide followed by quenching with trifluoromethanesulfonic acid. The structure of **5** was established by X-ray crystallography.
- 6 For the use of Bmt group in the synthesis of sulfur and selenium compounds with unique reactivity, see: K. Goto, M. Holler, and R. Okazaki, *Tetrahedron Lett.*, **37**, 3141 (1996); K. Goto, M. Holler, and R. Okazaki, *J. Am. Chem. Soc.*, **119**, 1460 (1997); K. Goto, M. Holler, and R. Okazaki, *Chem. Commun.*, **1998**, 1915; K. Goto, Y. Hino, Y. Takahashi, T. Kawashima, G. Yamamoto, N. Takagi, and S. Nagase, *Chem. Lett.*, **2001**, 1204; M. Itoh, K. Takenaka, R. Okazaki, N. Takeda, and N. Tokitoh, *Chem. Lett.*, **2001**, 1206; K. Goto, M. Nagahama, T. Mizushima, K. Shimada, T. Kawashima, and R. Okazaki, *Org. Lett.*, **3**, 3569 (2001).
- 7 The new compounds **6**–**8**, **11**, **13**, and **14** were characterized by ¹H and ¹³C NMR and X-ray crystallography.
- 8 Dimerization of acyllithium **1** of a similar structure was postulated to explain the formation of RC(=O)CHR(OH) and RC(=O)CR(=O): L. S. Trzupke, T. L. Newirth, E. G. Kelly, N. E. Sbarbati, and G. M. Whitesides, *J. Am. Chem. Soc.*, **95**, 8118 (1973); N. S. Nudelman and A. A. Vitale, *J. Org. Chem.*, **46**, 4625 (1981).
- 9 An alternative pathway to **6** described below, i.e., the reaction of **9** with **5** giving thiolate **I** followed by its deprotonation with LiTMP, is considered to be unlikely, though not completely excluded, because the reaction of BmtLi with carbon disulfide followed by quenching with methyl iodide at -78°C also gave **6** (55%). The detailed discussion of the reaction mechanism will be reported elsewhere.



10 For a review, see: E. K. Moltzen, K. J. Klabunde, and A. Senning, *Chem. Rev.*, **88**, 391 (1988).

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