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

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(Received September 12, 2005; CL-051164)

Deprotonation of aryl methanedithioate **5** bearing a bowl-type bulky subsituent with lithium tetramethylpiperidide 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.

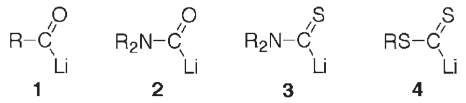
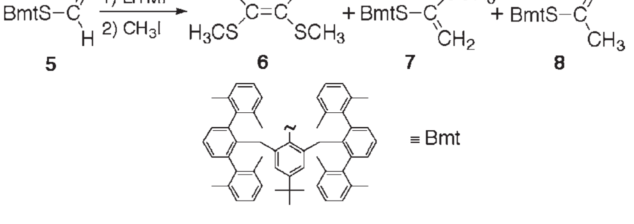


Chart 1.

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]phenyl[6] (denoted as Bmt hereafter) was allowed to react with lithium 2,2,6,6-tetramethylpiperidide (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 mechanisim for the formation of **6**–**8** is shown in Scheme 2. Alkene **6** is most likely produced by dimerization[8,9] 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.

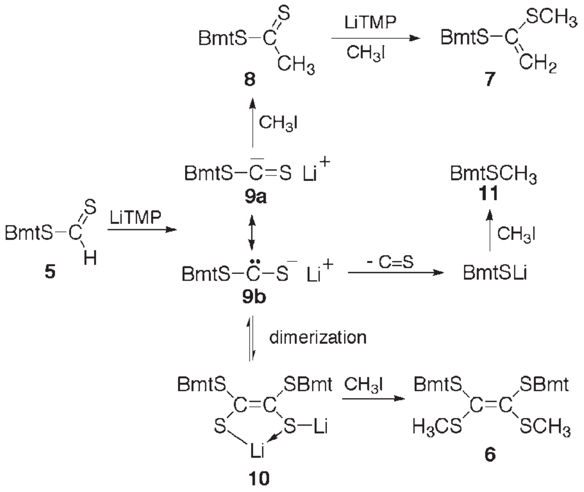


Scheme 1.

Table 1. Deprotonation of **5** with LiTMP followed by quenching with CH_3I[a]

Entry	React. conditions[b]	CH_3I/equiv.	Yield/% **6**	Yield/% **7**	Yield/% **8**	Yield/% **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

[a]Deprotonation in all reactions was carried out at −98 °C. [b]The reaction conditions indicate temperature and time before treatment with CH_3I. [c]The starting material **5** was recovered in 7%.



Scheme 2.

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%).

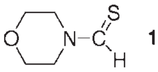


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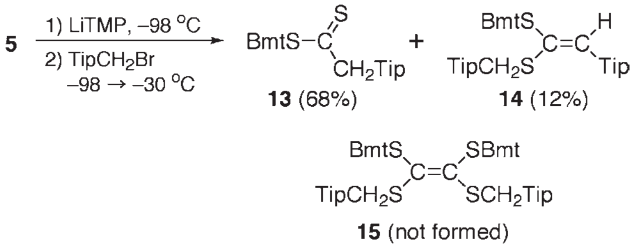
Chart 2.

Carbon monosulfide is a useful building block of thiocarbonyl compounds and known to be highly reactive[10] 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, $TipCH_2Br$ (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 $TipCH_2Br$ 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.

We thank Dr. M. Minoura of Kitasato University for X-ray crystallography and Dr. N. Kano of the University of Tokyo for ^{13}C NMR. This work was partially supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

References and Notes

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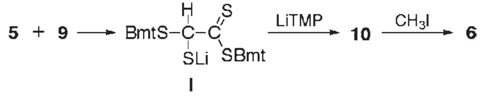
5 Methanedithioate **5** was synthesized in 74% by the reaction of BmtLi, generated by lithiation of BmtBr with *t*-BuLi at −78 °C, with carbon disulfide followed by quenching with trifluoromethanesulfonic acid. The structure of **5** was established by X-ray crystallography.

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 ^{13}C 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. Trzupek, 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.



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

11 a) E. K. Moltzen, B. Jensen, and A. Senning, *Acta Chem. Scand., Ser. B*, **B40**, 609 (1986). b) E. K. Moltzen, M. P. Kramer, A. Senning, and K. J. Klabunde, *J. Org. Chem.*, **52**, 1156 (1987).

Published on the web (Advance View) November 19, 2005; DOI 10.1246/cl.2005.1674