SYNLETT Spotlight 361

Sodium Dithionite

Compiled by Xiao-Nan Zhang

This feature focuses on a reagent chosen by a postgraduate, highlighting the uses and preparation of the reagent in current research

Xiao-Nan Zhang was born in Baoding, Hebei Province, P. R. of China. She graduated from the Hebei Normal University and received her B.Sc. in chemistry in 2009. Currently, she is working toward her M.Sc. degree under the supervision of Professor Zhan-Hui Zhang at the same university. Her research interests focus on the development of new reagents and catalysts in organic synthesis.

The College of Chemistry & Material Science, Hebei Normal University, Shijiazhuang 050016, P. R. of China
E-mail: zhangxn0911@163.com

Introduction

Sodium dithionite (also known as sodium hydrosulfite) is a versatile, inexpensive, safe and readily available reagent, which has been employed for more than 70 years. It has been used in biochemistry for the reduction of a variety of coenzymes and enzymes, and in organic synthesis to reduce several types of functional groups, such as aldehydes, ketones, imines, pyrazine, vinyl sulfones, nitro¹ and azo groups,² oximes,³ enones,⁴ quinones,⁵ and azides.⁶ It was also found to be an efficient reagent for the reductive displacement of iodine⁷ and reductive coupling of benzylic and allylic halides.⁸ It has been also used as radical initiator to promote coupling of CF₃CHClBr with 1,3,5-trimethoxybenzene,⁹ the addition of 1-bromo-1-chloro-2,2,2-trifluoroethane to the terminal double bond of

allylbenzenes,¹⁰ addition reaction of perfluoroalkyl iodides with allenes,¹¹ the reaction of polyfluoroalkyl iodides with alkenes,¹² addition of dialkyl phosphonodifluoromethyl radical onto unsaturated ketones,¹³ fluoroalkylation of porphyrins¹⁴ and vinyl ethers.¹⁵ This reagent is found to be a useful reagent in the intramolecular Marschall cyclization¹⁶ and Claisen rearrangement.¹⁷

Sodium dithionite is now commercially available, but can also be prepared readily by the reaction of sodium bisulfite with zinc.¹⁸ It is obtained as a white crystalline powder with a weak sulfurous odor. This compound is stable under most conditions, but it will decompose in hot water and in acid solutions.

Scheme 1

Abstracts

(A) Reduction of Quinones to Hydroquinones:

Suzuki and co-workers showed that 2,5-dihalobenzoquinones could be reduced to the corresponding hydroquinones with aqueous sodium dithionite in high yield.¹⁹

(B) One-Pot Synthesis of Benzimidazoles via Reductive Cyclization:

A highly efficient procedure for the preparation of benzimidazoles in one step by the reduction of *o*-nitroanilines with sodium dithionite in the presence of aldehydes in ethanol is achieved.²⁰ Only monosubstituted benzimidazole was obtained in this procedure. Furthermore, this method was applied to the synthesis of imidazole-containing heterocyclic ring systems.

(C) Thioamides from Nitriles and Phosphorus Pentasulfide:

Goswami and co-workers reported that aliphatic, aromatic, and heterocyclic nitriles can be thionated to give the corresponding primary thioamides using a reagent system of phosphorus pentasulfide and sodium dithionite or sodium sulfite.²¹ The thionating nucleophile PS₃⁻ is probably generated by reducing the weak P=S or reductively cleaving the P-S bond of P₄S₁₀ using this reagent system. It attacks the electrophilic carbon of the cyano group to afford thioamide after aqueous work-up.

(D) *One-Pot Synthesis of Sulfides by Reaction of Aryl Disulfides with Alkyl Halides:*

A mild method for the synthesis of unsymmetrical sulfides by reaction of diaryl disulfides with alkyl halides has been developed. Sodium dithionite is speculated to form a radical anion and serves as a source of electrons for the cleavage of the S–S bond or for the dehalogenation of alkyl halides.²²

(E) *Fluoroalkylation of 1,3,5-Trimethoxybenzene:*

Sodium dithionite can be applied as a radical initiating reagent for fluoroalkylation of 1,3,5-trimethoxybenzene with CF₃CHClBr in acetonitrile–water to afford trifluoromethylbis(2,4,6-trimethoxyphenyl)methane as the only isolated product.²³

(F) *Regio- and Stereoselective Addition of Perfluoroalkyl Iodides to Allenes:*

Sodium dithionite has successfully been used as initiator for the selective addition of perfluoroalkyl iodides to various allenes conjugated with a C=O or a P=O double bond. Perfluoroalkyl groups were introduced into the terminal position of allenes regioselectively and adducts with the *E*-configuration were obtained stereoselectively.²⁴

(G) *Synthesis of Symmetric Dibenzyl Sulfones:*

Li et al. have reported a one-step synthesis of symmetric dibenzyl sulfones by reaction of sodium dithionite with benzyl chloride in the ionic liquid 1-butyl-3-methylimidazolium tetrafluoroborate ([bmim]BF₄).²⁵

(H) *Synthesis of 2-Arylbenzothiazoles:*

Chen and co-workers showed that sodium dithionite can promote the synthesis of 2-arylbenzothiazoles by reaction of 2,2'-disulfanediyldianiline with aldehydes in the presence of sodium dodecyl sulfate in water.²⁶

References

- (1) (a) Pantos, G. D.; Rodríguez-Morgade, M. S.; Torres, T.; Lynch, V. M.; Sessler, J. L. *Chem. Commun.* **2006**, 2132. (b) Al-Huniti, M. H.; Zahra, J. A.; El-Abadelah, M. M. *Heterocycles* **2007**, 71, 411. (c) Akiyama, T.; Uoyama, H.; Okujima, T.; Yamada, H.; Ono, N.; Uno, H. *Tetrahedron* **2009**, 65, 4345.
- (2) (a) Sydnese, M. O.; Kuse, M.; Doi, I.; Isobe, M. *Tetrahedron* **2009**, 65, 3863. (b) Sydnese, L. K.; Elmi, S.; Heggen, P.; Holmelid, B.; Malthe-Sorensen, D. *Synlett* **2007**, 1695.
- (3) Müller, C. E.; Roegler, C.; Hockemeyer, J. *Heterocycles* **2009**, 79, 703.
- (4) Li, Z.; Watkins, E. B.; Liu, H.; Chittiboyina, A. G.; Carvalho, P. B.; Avery, M. A. *J. Org. Chem.* **2008**, 73, 7764.
- (5) (a) Zhang, Y. Z.; Aouadi, K.; Chen, G.-R.; Praly, J.-P. *Synthesis* **2007**, 3473. (b) Conchon, E.; Anizon, F.; Aboab, B.; Prudhomme, M. *Synthesis* **2008**, 2569.
- (6) Mekheimer, R. A.; Ibrahim, Y. R.; Ahmed, E. A.; Frey, W. *Tetrahedron* **2009**, 65, 9843.
- (7) Ponzinibbio, A.; Colinas, P. A.; Lieberknecht, A.; Bravo, R. D. *Lett. Org. Chem.* **2006**, 3, 459.
- (8) Khurana, J. M.; Bansal, G.; Sahoo, P. K. *J. Chem. Res.* **2004**, 139.
- (9) Dmowski, W.; Urbanczyk-Lipkowska, Z.; Wojcik, D. *J. Fluorine Chem.* **2009**, 130, 509.
- (10) Ignatowska, J.; Dmowski, W. *J. Fluorine Chem.* **2006**, 127, 720.
- (11) Ma, Z. C.; Ma, S. M. *Tetrahedron* **2008**, 64, 6500.
- (12) (a) Yang, X. Y.; Wang, Z. H.; Fang, X.; Yang, X. J.; Wu, F. H.; Shen, Y. J. *Synthesis* **2007**, 1768. (b) Ma, Z. C.; Ma, S. M. *Tetrahedron* **2008**, 64, 6500.
- (13) Sene, A.; Diab, S.; Hienzsch, A.; Cahard, D.; Lequeux, T. *Synlett* **2009**, 981.
- (14) (a) Chen, L.; Jin, L. M.; Guo, C. C.; Chen, Q. Y. *Synlett* **2005**, 963. (b) Chen, L.; Jin, L. M.; Xiao, J. C.; Guo, C. C.; Chen, Q. Y. *Synlett* **2007**, 2096.
- (15) Valdersnes, S.; Sydnese, L. K. *Eur. J. Org. Chem.* **2009**, 5816.
- (16) Suzuki, F.; Trenbeath, S.; Gleim, R. D.; Sih, C. J. *J. Am. Chem. Soc.* **1978**, 100, 2272.
- (17) Boddy, I. K.; Boniface, P. J.; Cambie, R. C.; Craw, P. A.; Larsen, D. S.; McDonald, H.; Rutledge, P. S.; Woodgate, P. D. *Tetrahedron Lett.* **1982**, 23, 4407.
- (18) Pratt, L. A. *Ind. Eng. Chem.* **1924**, 16, 676.
- (19) Suzuki, K.; Hintermann, L. *Synthesis* **2008**, 2303.
- (20) Yang, D. L.; Fokas, D.; Li, J. Z.; Yu, L. B.; Baldino, C. M. *Synthesis* **2005**, 47.
- (21) Goswami, S.; Maity, A. C.; Das, N. K. *J. Sulfur Chem.* **2007**, 28, 233.
- (22) Tang, R.-Y.; Zhong, P.; Lin, Q.-L. *Phosphorus Sulfur Silicon Relat. Elem.* **2007**, 182, 167.
- (23) Dmowski, W.; Urbanczyk-Lipkowska, Z.; Wójcik, D. *J. Fluorine Chem.* **2009**, 130, 509.
- (24) Mei, Y.-Q.; Liu, J.-T.; Liu, J.-J. *Synthesis* **2007**, 739.
- (25) Li, Y.-Q.; Zhang, L.-P. *Monatsh. Chem.* **2006**, 137, 1315.
- (26) Yang, X. L.; Xu, Y. L.; Chen, J. X.; Ding, J. C.; Wu, H. Y.; Su, W. K. *J. Chem. Res.* **2009**, 682.