

This article was downloaded by:

On: 27 January 2011

Access details: Access Details: Free Access

Publisher Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Phosphorus, Sulfur, and Silicon and the Related Elements

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t713618290>

(PhCH₂PPh₃)⁺Br₃⁻: A Versatile Reagent for the Preparation, Deprotection, and Oxidation of Trimethylsilyl Ethers

F. Shirini^a; G. H. Imanzadeh^b; A. R. Mousazadeh^{ab}; I. Mohammadpoor-Baltork^c; A. R. Aliakbar^a; M. Abedini^a

^a Department of Chemistry, College of Science, University of Guilan, Rasht, Iran ^b Department of Chemistry, College of Science, University of Mohaghegh-Ardabili, Ardabil, Iran ^c Department of Chemistry, Isfahan University, Isfahan, Iran

Online publication date: 24 February 2010

To cite this Article Shirini, F. , Imanzadeh, G. H. , Mousazadeh, A. R. , Mohammadpoor-Baltork, I. , Aliakbar, A. R. and Abedini, M.(2010) '(PhCH₂PPh₃)⁺Br₃⁻: A Versatile Reagent for the Preparation, Deprotection, and Oxidation of Trimethylsilyl Ethers', Phosphorus, Sulfur, and Silicon and the Related Elements, 185: 3, 641 — 646

To link to this Article: DOI: 10.1080/10426500902915440

URL: <http://dx.doi.org/10.1080/10426500902915440>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

(PhCH₂PPh₃)⁺Br₃[−]: A VERSATILE REAGENT FOR THE PREPARATION, DEPROTECTION, AND OXIDATION OF TRIMETHYLSILYL ETHERS

**F. Shirini,¹ G. H. Imanzadeh,² A. R. Mousazadeh,^{1,2}
I. Mohammadpoor-Baltork,³ A. R. Aliakbar,¹ and M. Abedini¹**

¹*Department of Chemistry, College of Science, University of Guilan, Rasht, Iran*

²*Department of Chemistry, College of Science, University of Mohaghegh-Ardabili, Ardabil, Iran*

³*Department of Chemistry, Isfahan University, Isfahan, Iran*

Benzyltriphenylphosphonium tribromide (BTPTB), as a stable solid reagent, is easily prepared by the reaction of benzyltriphenylphosphonium bromide with Br₂. This reagent can be used as an efficient catalyst for the conversion of alcohols to their corresponding trimethylsilyl ethers (TMS ethers) with hexamethyldisilazane (HMDS). Desilylation of TMS ethers is also catalyzed by BTPTB in MeOH at room temperature in high yields. BTPTB is also able to oxidize the TMS ethers to their corresponding carbonyl compounds in a mixture of MeOH/H₂O in good to high yields.

Supplemental materials are available for this article. Go to the publisher's online edition of Phosphorus, Sulfur, and Silicon and the Related Elements to view the free supplemental file.

Keywords Alcohols; benzyltriphenylphosphonium tribromide; deprotection; oxidation; trimethylsilyl ethers

INTRODUCTION

During a multistep synthesis, different methods are used for the protection of alcoholic hydroxyl groups, in which trimethylsilylation is one of the most widely used methods for this purpose.¹ Because of its availability, cheapness, and stability, hexamethyldisilazane (HMDS) is considered as one of the most useful reagents for this protection. Even though the handling of HMDS is easy, and silylation using this reagent does not need special precautions, the low silylating power is the main drawback to its application. To improve the silylating power of this reagent, a variety of catalysts have been reported; of them, sulfonic acid,² K-10 montmorillonite,³ silica chloride,⁴ KBr,⁵ Al(HSO₄)₃,⁶ Fe(HSO₄)₃,⁷ ZrCl₄,⁸ tungstophosphoric acid,⁹ lithium perchlorate,¹⁰ cupric sulfate pentahydrate,¹¹ Al(OTf)₃,¹² magnesium triflate,¹³ copper triflate,¹⁴ trichloroisocyanuric acid,¹⁵

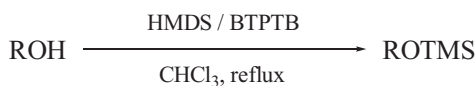
Received 16 December 2008; accepted 13 March 2009.

We are thankful to the University of Guilan and Mohaghegh-Ardabili University Research Councils for the partial support of this work.

Address correspondence to Dr. Farhad Shirini, Department of Chemistry, College of Science, The University of Guilan, Rasht 41335, Iran. E-mail: shirini@guilan.ac.ir

sulfonic acid-functionalized nanoporous silica,¹⁶ iodine,¹⁷ H- β zeolite,¹⁸ lanthanum trichloride,¹⁹ mono- and dibromo-5,5-diethylbarbituric acids,²⁰ 1,3-dibromo-5,5-diethylbarbituric acid,²¹ $\text{HClO}_4 \cdot \text{SiO}_2$,²² NH_4SCN ,²³ and tribromomelamine²⁴ are examples. Although these procedures are an improvement, most of them suffer from disadvantages such as long reaction times, forceful conditions, low selectivity, tedious workup, and use of toxic, expensive, or moisture-sensitive reagents. Hence introduction of new procedures to circumvent these problems is still in demand.

Very recently, benzyltriphenylphosphonium tribromide (BTPTB) was used in the tetrahydropyranylation of alcohols²⁵ as well as the thioacetalization of carbonyl compounds.²⁶ In continuation of our ongoing research program on the development of new methods for the protection of hydroxyl groups,^{4–8, 27, 28} herein, in addition to the introduction of a new and high yielding method for the preparation of BTPTB, we report the applicability of this reagent in the promotion of the trimethylsilylation of alcohols with HMDS (Scheme 1).



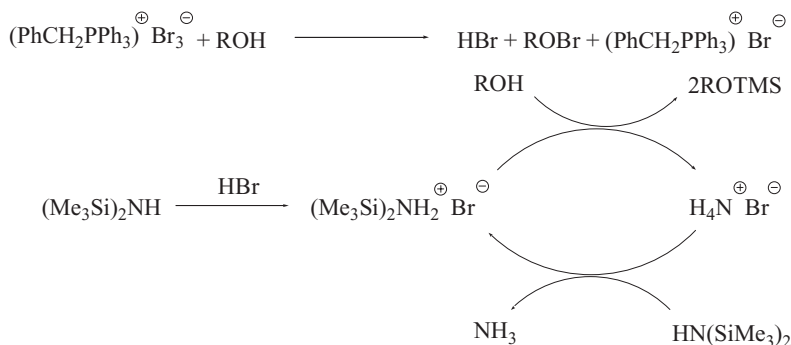
Scheme 1

Initially, 4-chlorobenzyl alcohol was chosen as a model substrate for the silylation reaction. It was treated with 2 eq. of HMDS in the presence of 0.01 eq. of BTPTB in CHCl_3 (2 mL) under reflux conditions, and the reaction was completed in 20 min (95% isolated yield). After optimization of the reaction conditions, different types of alcohols, including benzylic and primary and secondary aliphatic alcohols, were subjected to trimethylsilylation under the determined conditions. As shown in Table I, the corresponding TMS ethers were obtained in short reaction times in good to high yields. No elimination and rearrangement byproducts were observed at all. Tertiary alcohols are silylated slower than the other alcohols using this method, and the reaction is incomplete in most cases (Table I, entries 13–15). Therefore this methodology can be used for the selective silylation of benzylic and primary and secondary aliphatic alcohols in the presence of tertiary alcohols. This is exemplified by the competitive reaction between 2-methylbenzyl alcohol and triphenylmethanol (Table I, entry 16).

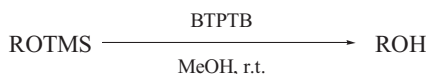
In 1987, Kajigaeshi et al. reported that organic ammonium tribromides, such as benzyltrimethylammonium tribromide, generate HBr and MeOBr in methanol.²⁹ On the basis of this and obtained results, the mechanism shown in Scheme 2 is selected as the most plausible one for trimethylsilylation of alcohols catalyzed by BTPTB.

Taking cues from the above-mentioned idea based on the probable generation of HBr from the reaction of MeOH and BTPTB, we decided to investigate the deprotection of TMS ethers in methanol using this reagent. Our investigation clarified that the conversion of TMS ethers to their corresponding alcohols is easily performed in the presence of catalytic amounts of BTPTB in MeOH. All reactions were performed at room temperature in short reaction times in high yields (Scheme 3, Table II). The probable mechanism of the reaction is shown in Scheme S1 (available online in the Supplementary Materials).

We have also found that by increasing the amounts of BTPTB, TMS ethers were efficiently converted to their corresponding aldehydes and ketones. All reactions were


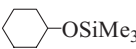
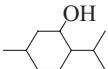
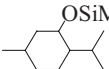
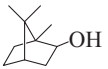

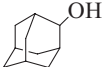
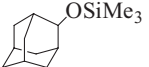
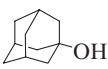
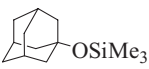


Scheme 2



Scheme 3

Table I Trimethylsilylation of alcohols^a

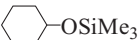



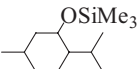

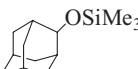

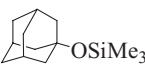

Entry	Substrate	Product	Time (min)	Yield (%) ^b
1	4-ClC ₆ H ₄ CH ₂ OH	4-ClC ₆ H ₄ CH ₂ OSiMe ₃	20	95
2	4-NO ₂ C ₆ H ₄ CH ₂ OH	4-NO ₂ C ₆ H ₄ CH ₂ OSiMe ₃	75	60
3	2-MeC ₆ H ₄ CH ₂ OH	2-MeC ₆ H ₄ CH ₂ OSiMe ₃	10	92
4	4-MeOC ₆ H ₄ CH ₂ OH	4-MeOC ₆ H ₄ CH ₂ OSiMe ₃	8	95
5	PhCH(OH)Ph	PhCH(OSiMe ₃)Ph	15	90
6	PhCH(OH)C(O)Ph	PhCH(OSiMe ₃)C(O)Ph	75	90
7	PhCH ₂ CH ₂ OH	PhCH ₂ CH ₂ OSiMe ₃	14	92
8	PhCH ₂ CH ₂ CH ₂ OH	PhCH ₂ CH ₂ CH ₂ OSiMe ₃	15	89
9			90	75
10			30	87
11			45	90
12			70	92
13	PhCH ₂ C(OH)Me ₂	PhCH ₂ C(OSiMe ₃)Me ₂	60	0
14	Ph ₃ COH	Ph ₃ COSiMe ₃	60	0
15			120	10
16	2-MeC ₆ H ₄ CH ₂ OH + Ph ₃ COH	2-MeC ₆ H ₄ CH ₂ OSiMe ₃ + Ph ₃ COSiMe ₃	10	100 ^c + 0 ^c

^aProducts were characterized by their physical data, comparison with authentic samples, and IR and NMR spectroscopy, and also by the conversion of silyl ethers to their corresponding alcohols.^{19, 22–24, 31, 32}

^bIsolated yield.

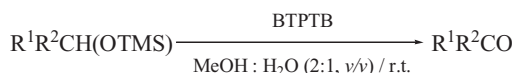
^cConversion.

Table II Deprotection of trimethylsilyl ethers^a

Entry	Substrate	Product	Time (min)	Yield (%) ^b
1	4-ClC ₆ H ₄ CH ₂ OSiMe ₃	4-ClC ₆ H ₄ CH ₂ OH	3	90
2	2-ClC ₆ H ₄ CH ₂ OSiMe ₃	2-ClC ₆ H ₄ CH ₂ OH	2	92
3	2-BrC ₆ H ₄ CH ₂ OSiMe ₃	2-BrC ₆ H ₄ CH ₂ OH	2	95
4	2-MeC ₆ H ₄ CH ₂ OSiMe ₃	2-MeC ₆ H ₄ CH ₂ OH	1	90
5	4-Me ₃ CC ₆ H ₄ CH ₂ OSiMe ₃	4-Me ₃ CC ₆ H ₄ CH ₂ OH	1	90
6	2-MeOC ₆ H ₄ CH ₂ OSiMe ₃	2-MeOC ₆ H ₄ CH ₂ OH	2	92
7	4-MeOC ₆ H ₄ CH ₂ OSiMe ₃	4-MeOC ₆ H ₄ CH ₂ OH	2	87
8	4-NO ₂ C ₆ H ₄ CH ₂ OSiMe ₃	4-NO ₂ C ₆ H ₄ CH ₂ OH	3	95
9	2-NO ₂ C ₆ H ₄ CH ₂ OSiMe ₃	2-NO ₂ C ₆ H ₄ CH ₂ OH	4	90
10	PhCH(OSiMe ₃)CH ₃	PhCH(OH)CH ₃	2	92
11	PhCH(OSiMe ₃)Ph	PhCH(OH)Ph	2	90
12	PhCH(OSiMe ₃)C(O)Ph	PhCH(OH)C(O)Ph	3	90
13	PhCH ₂ CH ₂ OSiMe ₃	PhCH ₂ CH ₂ OH	2	85
14	PhCH ₂ CH ₂ CH ₂ OSiMe ₃	PhCH ₂ CH ₂ CH ₂ OH	3	90
15			2	95
16			3	90
17			3	85
18			2	90
19			3	85

^aProducts are characterized by IR, NMR, elemental analysis, and comparison with authentic samples.^bIsolated yield.

performed in a mixture of MeOH and H₂O (2:1, v/v) at room temperature in good to high yields [Scheme 4, Table S1 (Supplementary Materials online)].

**Scheme 4**

Our studies revealed that the reaction consists of two steps: deprotection of TMS ethers and oxidation of the produced alcohols. On the basis of these results and the literature,³⁰ the mechanism of the reaction can be suggested, which is shown in Scheme S2 (Supplementary Materials online).

In conclusion, we have reported the application of benzyltriphenylphosphonium tribromide in the efficient trimethylsilylation of alcohols, as well as in the deprotection and oxidation of silyl ethers. Relatively short reaction times, high yields of the products, and easy workup are important advantages of this method, which make this procedure a useful and attractive addition to the currently available methods.

EXPERIMENTAL

Chemicals were purchased from Fluka, Merck, and Aldrich Chemical Companies. Yields refer to isolated products. Products were characterized by their physical constants, comparison with authentic samples, and IR and NMR spectroscopy.^{19, 22–24, 31, 32}

Preparation of BTPTB

A 0.5 M solution (1 mL) of Br₂ in MeOH was added dropwise to a solution of benzyltriphenylphosphonium bromide (0.3 mmol, 0.13 g) in EtOH (5 mL) with stirring in an ice bath. The mixture was stirred for 1 h, then filtered. The yellow solid residue was washed with distilled water, dried at room temperature, and recrystallized from CH₃CN to give BTPTB in 85% yield.

Trimethylsilylation of Alcohols Catalyzed by BTPTB

A mixture of the substrate (1 mmol), HMDS (2 mmol, 0.32 g), and BTPTB (0.01 mmol, 0.006 g) in CHCl₃ (2 mL) was stirred under reflux conditions. The progress of the reaction was monitored by TLC. Upon completion, a saturated solution of sodium bicarbonate (5 mL) was added, and the product was extracted with CHCl₃ (2 × 10 mL). The organic layer was separated, washed with water, and dried over MgSO₄. The solvent was removed to give crude TMS ether. Further purification proceeded by bulb-to-bulb distillation under reduced pressure or recrystallization to afford pure silyl ether.

Deprotection of Trimethylsilyl Ethers Catalyzed by BTPTB

A mixture of the substrate (1 mmol) and BTPTB (0.025 mmol, 0.015 g) in MeOH (2 mL) was stirred at room temperature. The progress of the reaction was monitored by TLC. After completion of the reaction, the solvent was evaporated and Et₂O (5 mL) was added. The mixture was filtered and the solid residue was washed with Et₂O (5 mL). The filtrate was washed with saturated solution of NaHCO₃ and H₂O and dried over MgSO₄. Evaporation of the solvent followed by column chromatography on silica gel gave the corresponding alcohols in good to high yields.

Oxidation of Trimethylsilyl Ethers Using BTPTB

BTPTB (2 mmol, 1.2 g) was added to a solution of the substrate (1 mmol) in MeOH:H₂O (2:1, v/v) (3 mL). The mixture was stirred at room temperature. After completion of the reaction, most of the solvent was evaporated, and Et₂O (5 mL) was added. The mixture was filtered and the solid residue was washed with Et₂O (5 mL). The filtrate was washed with a saturated solution of NaHCO₃ and H₂O and dried over MgSO₄. Evaporation of the solvent followed by column chromatography on silica gel gave the corresponding carbonyl compounds in good to high yields.

REFERENCES

1. T. W. Greene and P. G. M. Wuts, *Protective Groups in Organic Synthesis*, 3rd ed. (Wiley, New York, 1999).
2. Goldschmidt AGT Ger Pat 2:758884 (1979).
3. Z. H. Zhang, T. S. Li, F. Yang, and C. G. Fu, *Synth. Commun.*, **28**, 3105 (1983).

4. F. Shirini, M. A. Zolfigol, and K. Mohammadi, *Phosphorous, Sulfur, and Silicon*, **178**, 1567 (2003).
5. F. Shirini and E. Mollarazi, *Synth. Commun.*, **36**, 1109 (2006).
6. F. Shirini, M. A. Zolfigol, and M. Abedini, *Bull. Chem. Soc. Jpn.*, **78**, 1982 (2005).
7. F. Shirini, M. A. Zolfigol, and A. R. Abri, *Monatsh. Chem.*, **139**, 17 (2008).
8. F. Shirini and E. Mollarazi, *Catal. Commun.*, **8**, 1393 (2007).
9. H. Firouzabadi, N. Iranpoor, K. Amani, and F. Nowrouzi, *J. Chem. Soc., Perkin Trans. 1*, 2601 (2002).
10. P. K. Bandgar and S. P. Kasture, *Monatsh. Chem.*, **132**, 1101 (2001).
11. B. Akhlaghinia and S. Tavakoli, *Synthesis*, 1775 (2005).
12. H. Firouzabadi, N. Iranpoor, S. Sobhani, and S. Gassamipour, *Synthesis*, 595 (2005).
13. H. Firouzabadi, N. Iranpoor, S. Sobhani, and S. Gassamipour, *J. Organomet. Chem.*, **689**, 3197 (2004).
14. H. Firouzabadi, N. Iranpoor, S. Sobhani, S. Gassamipour, and Z. Amoozgar, *Tetrahedron Lett.*, **44**, 891 (2003).
15. A. Khazaei, M. A. Zolfigol, A. Rostami, and A. GhorbaniChoghamarani, *Catal. Commun.*, **8**, 543 (2007).
16. D. Zareyee and B. Karimi, *Tetrahedron Lett.*, **48**, 1277 (2007).
17. B. Karimi and B. Golshani, *J. Org. Chem.*, **65**, 7228 (2000).
18. V. H. Tillu, V. H. Jadhav, H. B. Borate and R. D. Wakharkar, *ARKIVOC*, 83 (2004).
19. A. V. Narsaiah, *J. Organomet. Chem.*, **692**, 3614 (2007).
20. A. Khazaei, M. A. Zolfigol, Z. Tanbakouchian, M. Shiri, A. Rostami, and H. Iloukhani, *J. Brazilian Chem. Soc.*, **18**, 239 (2007).
21. A. Khazaei, M. A. Zolfigol, Z. Tanbakouchian, M. Shiri, K. Niknam, and J. Saien, *Catal. Commun.*, **8**, 917 (2007).
22. H. R. Shaterian, F. Shahrekipoor, and M. Ghashang, *J. Mol. Catal. A: Chem.*, **272**, 142 (2007).
23. V. H. Jadhav, K. S. Kumar, V. D. Chadhari, and D. D. Dhavale, *Synth. Commun.*, **37**, 1363 (2007).
24. A. Ghorbani-Choghamarani, M. A. Zolfigol, M. Hajjami, and S. Jafari, *J. Chinese Chem. Soc.*, **55**, 1208 (2008).
25. A. R. Hajipour, S. A. Pourmousavi, and A. E. Ruoho, *Synth. Commun.*, **35**, 2894 (2005).
26. A. R. Hajipour, S. A. Pourmousavi, and A. E. Ruoho, *Synth. Commun.*, **38**, 2548 (2008).
27. P. Salehi, M. A. Zolfigol, F. Shirini, and M. Baghbanzadeh, *Current Org. Chem.*, **10**, 2171 (2006).
28. F. Shirini, M. A. Zolfigol, P. Salehi, and M. Abedini, *Current Org. Chem.*, **12**, 183 (2008).
29. S. Kajigaeshi, T. Kakinami, and T. Hirakawa, *Chem. Lett.*, 627 (1987).
30. M. Baghmar and P. K. Sharma, *Proc. Indian Acad. Sci. (Chem. Sci.)*, **113**, 139 (2001).
31. W. Gerrard and K. D. Kilburn, *J. Am. Chem. Soc.*, 1536 (1956).
32. I. Nishiguchi, Y. Kita, M. Watanabe, Y. Ishino, T. Ohno, and H. Maekawa, *Synlett*, 1025 (2000).