

Note

A simple method for deprotection of *tert*-butyldimethylsilyl ethers by using stannous chloride under microwave irradiation

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A facile regeneration of hydroxy compounds from their *tert*-butyldimethylsilyl ethers in presence of stannous chloride under solvent free conditions using domestic microwave oven has been performed efficiently in a short period (5-6 min). The conversion using stannous chloride in ethanol or water for comparison of the efficiency has been described. The generality of the transformation has been confirmed by several examples.

Keywords: *tert*-Butyldimethylsilyl ethers, stannous chloride, deprotection, microwave

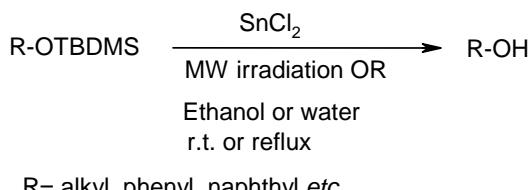
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The scientific community uses a large number of protecting groups for various functionalities routinely in synthetic organic chemistry. *tert*-Butyldimethylsilylation of alcohols and phenols is a versatile method because these silyl ethers are stable under a variety of conditions like Wittig reaction, Grignard reaction, reductions with diisobutylaluminium hydride, etc. The enormous work in the silylation chemistry has resulted in the development of various methods for silylation and desilylation¹. Recently BiCl₃-NaI², triethylamine N-oxide³, cerium (IV) triflate⁴, cesium carbonate⁵, acetyl chloride⁶, bromodimethylsulfonium bromide⁷, SbCl₅⁸, iodine⁹, CBr₄¹⁰ etc have been reported for the deprotection of *tert*-butyldimethylsilyl ethers indicating the importance of this conversion in organic synthesis. SnCl₂ is an easily available, stable and cheap reagent. It is widely used in the food industry as a preservative and as colour retention agent¹¹. It also finds applications in various organic conversions including reduction, dehalogenation, etc¹². Recent reports include the applications of SnCl₂ in glycosylation¹³, allylation of aldimines¹⁴, esterification¹⁵, cleavage of

semicarbazones, phenyl hydrazones, oximes etc¹⁶. Cort reported¹⁷ deprotection of *tert*-butyldimethylsilyl ether of cyclohexanol and 1-decanol using SnCl₂ in acetonitrile but its potential has not been exploited fully as there is no other report about deprotection of other substrates or use of other solvents. We considered that environmentally benign method for deprotection of *tert*-butyldimethylsilyl ethers could be developed using SnCl₂. In the present communication, the deprotection of a number of *tert*-butyldimethylsilyl ethers in presence of SnCl₂ under microwave irradiation in solvent free conditions has been described (**Scheme I**). The utility of SnCl₂ for the cleavage of *tert*-butyldimethylsilyl ethers in ecofriendly solvents such as ethanol and water at RT as well as at reflux was also explored which was substantiated by several examples as shown in **Table I**.

Results and discussion

Various alcoholic and phenolic *tert*-butyldimethylsilyl ethers were initially treated with an equimolar quantity of SnCl₂ in ethanol at RT. It was observed that they were converted to the corresponding alcohols and phenols in good yields in 5 to 7 hr (**Table I**). When the reactions were carried out at 80°C, the duration of the reaction was reduced to 35-40 min to afford the products in comparable yields. Similarly, replacing ethanol by water as solvent in the above experiments under reflux conditions afforded the desilylated products. **Table I** exhibits efficiency of the method under aqueous conditions leading to good yields. Further utility of SnCl₂ for this transformation under solvent free conditions was also explored using microwave irradiation technique wherein comparable results were achieved in much shorter time i.e. 5 to 7 min. Thus, *tert*-butyldimethylsilyl ethers of various alcohols, phenols and



Scheme I

Table I—Deprotection of *tert*-butyldimethylsilyl ethers with SnCl_2 under different conditions

Entry No.	TBDMS ether of	Ethanol at RT		Ethanol at reflux		Water at reflux		MW irrad.	
		time (hr)	yield (%) ^a	time (min)	yield (%) ^a	time (hr)	yield (%) ^a	time (min)	yield (%) ^a
1	Cyclohexanol	6	89	40	85	4	83	5	85
2	Phenol	5	90	35	88	3	82	5	87
3	Guaiacol	5	85	35	83	3	85	5	89
4	4-Methoxyphenol	5	82	35	85	3	80	5	82
5	Benzyl alcohol	6	80	45	87	4	82	6	85
6	3-Methylphenol	5	87	35	90	3	85	5	90
7	Isovanillin	5	85	35	85	3	80	5	83
8	Vanillin	5	89	35	90	3	87	5	90
9	3-Hydroxy-4-methoxy-benzylalcohol(3-OH protected)	5	86	35	87	3	85	5	83
10	3-Hydroxy-4-methoxy benzylalcohol(di-TBDMS)	7	90	40	90	4	87	6	89
11	3-Hydroxy-4-methoxy-benzyl acetate	5	92	35	90 ^b	3	90	5	91 ^b
12	2-Aminophenol	5	88	35	85	3	83	5	85
13	2-Hydroxyacetanilide	5	85	35	85 ^c	3	85	5	87 ^c
14	2-Hydroxyacetophenone	5	83	35	80	3	82	5	86
15	4-Bromo-2-Chlorophenol	5	87	35	83	3	83	5	85
16	1-Naphthol	ND	ND	ND	ND	5	82	7	85
17	2-Naphthol	ND	ND	ND	ND	5	85	7	83
18	2-Methoxy-1-naphthylmethanol	ND	ND	ND	ND	6	87	5	82
19	4-Methoxy-1-naphthylmethanol	ND	ND	ND	ND	6	85	5	83
20	Furfuryl alcohol	ND	ND	ND	ND	5	85	5	85

a = Isolated yields; b = Acetate group got cleaved; c = Acetate remained intact; ND = Not Done

naphthols bearing different substituents were deprotected using SnCl_2 under microwave conditions. It was observed that the yields were consistent (80-90%) under all different conditions described above. It is noteworthy that acetate of benzylic alcohol (**Table I**, entry no 11) got cleaved whereas acetanilide (**Table I**, entry no 13) was stable under these reaction conditions. All the products obtained were confirmed by comparing the spectral data with those reported in literature.

Experimental Section

All solvents and chemicals used were procured from S.D. Fine-Chem. Ltd Mumbai or Sigma-Aldrich Fine Chemicals. Infrared spectra were recorded on an ATI MATTSON RS-1 FT-IR spectrometer and ^1H NMR spectra on a Bruker AC-200 spectrometer. Reactions under microwave irradiation were carried out in a beaker in LG domestic microwave oven adjusted at 540 W and 180°C .

General procedures for deprotection of *tert*-butyldimethylsilyl ethers.

(A) Using ethanol as a solvent

$\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ (1 mmole) was added to a solution of *tert*-butyldimethylsilyl ether (1 mmole) in ethanol

(20 mL) and the reaction mixture was stirred at r.t. or under reflux till it was found to be complete (monitored by TLC). The solvent was then removed under vacuum, the residue was diluted with water to dissolve the tin salts and the product was extracted with ethyl acetate. The organic layer was washed with water and dried over anhydrous Na_2SO_4 . The solvent was removed and the crude product was purified by column chromatography over silica gel to afford pure products in 80 to 90% yields.

(B) Using water as a solvent

A procedure as in (A) above was followed under reflux using water as a solvent. After completion of reaction, the reaction mixture was diluted with water (10 mL) and worked up as in (A) to isolate pure products in 83 to 90% yields.

(C) Under microwave irradiation

The reaction was conducted without solvent in a microwave oven. After completion of reaction, the residue was taken up in ethyl acetate (20 mL/mmole of starting *tert*-butyldimethylsilyl ether) and filtered to remove tin salts. The filtrate was concentrated and the product was purified by column chromatography to collect the pure products in 82 to 91% yields.

In conclusion, we have demonstrated the utility of SnCl_2 for deprotection of *tert*-butyldimethylsilyl ethers under various conditions. The reactions can be performed in ethanol or water. It is also noteworthy that the same efficiency is observed under solvent free conditions using microwave irradiation in much shorter time (~ 5 min).

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