

# Deprotection of Tetrahydropyranyl Ethers Using a Catalytic Amount of Decaborane

Yeon Joo Jung, Eun Soo Park, Ji Hee Lee, and Cheol Min Yoon\*

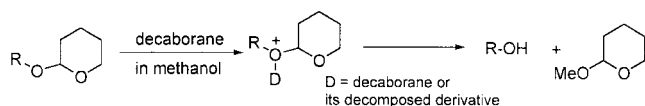
Graduate school of Biotechnology, Korea University, Seoul 136-701, Korea

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Selective introduction and removal of protecting groups of alcohols are of great significance in organic synthesis. Tetrahydropyranlation of alcohol has been recognized as an useful and common method for protection of alcohols because of its easy installation and stability to neutral and basic condition, even if there is a drawback that new chiral center at THP is formed.<sup>1</sup> A variety of deprotection methods of tetrahydropyranyl group in the presence of other functional groups were carried out under acidic,<sup>2</sup> neutral,<sup>3</sup> and reductive<sup>4</sup> methods. Most of these methods involve tedious work-up, heating, highly toxic reagents, quantitative amount of reagents and formation of considerable amount of side products. A new method that would effect the selective removal of THP ethers and be simple in work-up still remains as a goal. Decaborane (B<sub>10</sub>H<sub>14</sub>)<sup>5</sup> is commercially available white crystalline solid and decompose slowly in the air. It is known that decaborane is a good Lewis acid that can form adducts with Lewis base (SH, NH, OH etc).<sup>6</sup> Lewis acid property of decaborane was observed and used in our reductive etherification<sup>7</sup> and reductive amination,<sup>8</sup> in which roles of decaborane were catalyst for the formation of intermediate as well as reducing agents of the intermediates. On the basis of the reported acid property<sup>6</sup> and our observations on two developed methods,<sup>7,8</sup> decaborane was developed and introduced as a new, mild and efficient catalyst in interconversion of acetals and carbonyls in the organic field.<sup>9</sup>

As an ongoing study on decaborane as a mild Lewis acid catalyst, we tried the deprotection of THP ethers and found that THP ethers were deprotected efficiently to the corresponding alcohols using a catalytic amount of decaborane in absolute methanol (Scheme 1). THP ethers used in this experiment were prepared from the corresponding alcohols using the well-known procedures (DHP and PPTS in CH<sub>2</sub>Cl<sub>2</sub>)<sup>10</sup> and subjected to deprotection using the catalytic amounts of decaborane in absolute MeOH at room temperature to give the corresponding alcohols in high yields. The reaction proceeds well with 1 mol % of decaborane, although 2 mole % of decaborane was used to reduce the reaction time considerably. Solvent appear to play an important role in the cleavage reaction. Among solvent systems tested with 4-bromophenol as a model (Table 1), absolute methanol



Scheme 1

**Table 1.** Deprotection of 4-bromophenol THP in various solutions

Entry	Solvent	Reaction time (h)
1	MeOH	0.5 h
2	MeOH:THF (1:1)	2.5 h
3	MeOH:H <sub>2</sub> O (10:1)	Incomplete after 6 h
4	EtOH	2.5 h
5	Propanol	No reaction

gave the best results and is generally recommended. Ethanol (entry 4) and a solution of THF and methanol (entry 2) were less efficient solvent systems. Whereas the reaction was slow<sup>11</sup> in a solution of water and methanol (entry 3), the reaction were totally ineffective in propanol (entry 5). We believe that the mechanism of the deprotection involve the coordination of decaborane or/and its decomposed derivatives to oxygen of THP ether to form oxonium ion followed by nucleophilic attack of methanol (Scheme 1).

Various THP ethers of primary, secondary, phenolic and allylic alcohols can be deprotected efficiently by using 1 mol % of decaborane in absolute methanol at r.t. and the efficiency of this method is illustrated using the examples shown in the Table 2. The other acid labile protecting groups such as methylenedioxy ether (entry 3) and *t*-Boc (entry 10) were remained completely intact under the reaction condition. The rearrangement of allylic position (entry 6) and elimination reaction (entry 4) was not observed under the reaction condition. THP ether of 4-hydroxybenzaldehyde using 1 mol% decaborane was deprotected slowly and incompletely in extended reaction time (48 hr) and the several other spots was observed in tlc (entry 2). Even if 5 mol of decaborane was used, the reaction was not complete. The work-up after 2 hr gave the alcohol in 82% yield and recovered substrate in 7% yield. The reason for incomplete reaction is not clear. The deprotection reactions of substrate with nitro substituent (entries 5 and 9) took 5 h for completion.

In conclusion, THP ethers of alcohols in absolute methanol were converted to the corresponding alcohols using a catalytic amount of decaborane (1 mole %) at r.t. under nitrogen in high yields. The advantage of our protocol are mild, efficient and tolerable to several acid-sensitive functionalities. The procedure and the work-up are simple.

## Experimental Section

**General Procedure:** Decaborane (1 mol %) was added to

**Table 2.** Deprotection of THP ether using decaborane in methanol.

Entry	Substrate <b>1</b>	Time (h)	Product <b>2</b> <sup>a</sup>	Yield <sup>b</sup> (%)
1		0.5		93
2 <sup>c</sup>		2		82
3		1		96
4		0.5		98
5		5		92
6		2		98
7		1		92
8		2		98
9		7		97
10		3.5		98
11	$\text{ClCH}_2\text{CH}_2\text{CH}_2\text{OTHP}$	1	$\text{ClCH}_2\text{CH}_2\text{CH}_2\text{OH}$	94
12	$\text{C}\equiv\text{CCH}_2\text{CH}_2\text{OTHP}$	1	$\text{C}\equiv\text{CCH}_2\text{CH}_2\text{OH}$	92
13		2		98
14 <sup>d</sup>	Cholesteryl-OTHP	3	Cholesteryl-OH	90

<sup>a</sup>All products gave spectra consistent with the assigned structures.

<sup>b</sup>Isolated yields. <sup>c</sup>5 mol % of decaborane was used. <sup>d</sup>A solution of THF and MeOH (1 : 1 by volume) was used to dissolve cholesterol THP ether.

a solution of THP ether (1 mmol) in absolute methanol (5 mL). The reaction mixture was stirred at r.t. under nitrogen and monitored by TLC using a solution of ethyl acetate and hexane (1 : 4). The reaction was concentrated and chromatographed on short pad of silica gel using 1% methanol in methylene chloride and results are shown in Table 2.

**4-hydroxybenzaldehyde:** To a solution of THP ether of

4-hydroxybenzaldehyde (260 mg, 1.25 mmol) in absolute methanol (5 mL) was added decaborane (7.5 mg, 5 mol%) and the resulting solution was stirred for 2 hr. Then, water was added, stirred for 5 min and concentrated under reduced pressure, chromatographed on a short pad of silica gel and concentrated to give 4-hydroxyphenol in 82% yield.

All of these products have been known and data of the products are consistent with those of known ones.

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- Even if a drop of water was added, the reaction was retarded clearly and the reaction was incomplete.