

oxidation, respectively. Experiments in D₂O showed similar results. Movements of a rather large number of solvent molecules with the redox process may indicate the complex nature of monolayer self-assembly/electrolyte interfacial region. More water molecules might be expected to be trapped in the self-assembly/solution interface. Recent EQCM data observed at electrodes modified with osmium polymer complexes also show that a number of water accompany the redox reaction of osmium (III/II) sites.⁸ The same type of EQCM experiments with the anions of ClO₄⁻ and Cl⁻ were performed to find the variation of the number of solvent molecules moving simultaneously with the first redox process of viologen. Equivalent molar mass (*M_{eq}*) was determined to be 240 and 598 for perchlorates and chlorides, respectively. Because the molar masses of the anions are 99.5 (ClO₄⁻) and 35.5 (Cl⁻), *M_{eq}* determined would imply the simultaneous movements of water molecules (ca. 8 H₂O for ClO₄⁻ and ca. 31 H₂O for Cl⁻) into the self-assembly during oxidation if a unidirectional transport and permselectivity of the film to anions are assumed. The results were again confirmed by separate experiments in D₂O instead of H₂O. Thus the *in situ* mass transport measurements indicate that the self-assembled molecular C₂₂VC₁ films formed on gold surfaces contain water molecules and become compact in the order Cl⁻ < TS⁻ < ClO₄⁻. Buttry recently reported that simultaneous incorporation of anions and solvent water into the electroactive self-assembled monolayers of ferrocenes occurs upon electrochemical oxidation of ferrocenes to ferrocenium ions.⁹ Therefore, it appears that self-assembled molecular films on electrode surfaces contain a number of solvent water molecules although they are believed to be firmly organized based on the blocking properties for the reduction of Ru(NH₃)₆³⁺ and believed to be hydrophobic because their formation is mainly due to intermolecular hydrophobic interactions. Further EQCM studies are in progress with the self-assembly of asymmetric viologens.

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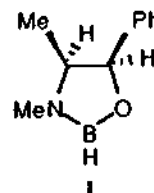
Asymmetric Borane Reduction of Ketoxime O-Trimethylsilyl Ethers Mediated by a Chiral 1,3,2-Oxazaborolidine Derived from (-)-Ephedrine

Byung Tae Cho* and Mi Hae Ryu

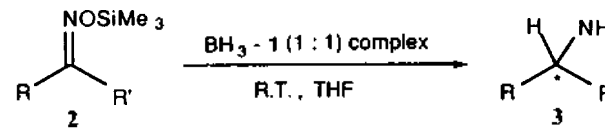
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One of the most convenient methods for the preparation of optically active primary amines is asymmetric reduction of ketoxime derivatives. However such reduction has been sparse and only very limited success has been achieved.¹ Very recently, we undertook the comparison study of asymmetric borane reduction of some representative ketimines and ketoxime ethers possessing C=N bond mediated by various chiral oxazaborolidines.² In this study, we found that a chiral oxazaborolidine **1** derived from (-)-ephedrine afforded the best result to give a high optical induction (90% ee) for acetophenone oxime O-trimethylsilyl ether **2d**. This result led us to investigate the asymmetric borane reduction of O-trimethylsilyl ethers **2** of other aliphatic and aromatic ketoximes, such as 2-butanone oxime **2a**, 4-methyl-2-pentanone oxime **2b**, 3-methyl-2-butanone oxime **2c**, propiophenone oximes **2e**, isobutyrophenone oxime **2f** pivalophenone oxime **2g** and tetralone oxime **2h**, using this reagent. All of the O-trimethylsilyl ethers of ketoximes examined were prepared by treatment of the corresponding ketoximes with chlorotrimethylsilane in the presence of triethylamine in THF.²



The reductions were carried out with 1 equiv of borane-THF in the presence of 1 equiv of **1** in THF at room temperature. Thus, the reductions of O-trimethylsilyl ethers of unhindered aliphatic ketoxime **2a** proceeded smoothly to give the corresponding primary amines **3a** in a high chemical yield with 38% ee. However, the reduction of O-trimethylsilyl ethers of relatively hindered aliphatic ketone oximes **2b-2c** proceeded at a somewhat slower rate to provide **3b** and **3c** with optical yields of 44% ee and 66% ee, respectively, showing the increase of optical induction by the variation of the steric size of R in MeCR=NOTMS from Et→i-Bu→i-Pr. The aromatic ketoxime derivatives **2d-2f** and **2h**

Table 1. Asymmetric Borane Reduction of Ketoxime *O*-Trimethylsilyl Ethers in the Presence of **1** in Tetrahydrofuran at Room Temperature^a


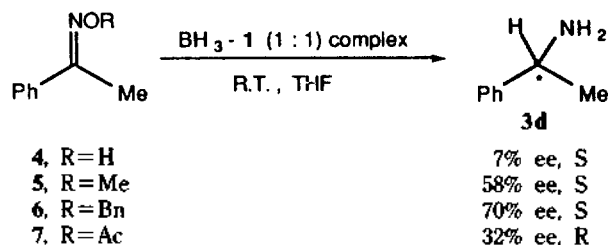
2		Time (h)	3		
R	R'		Yield(%) ^b	% ee ^c	Abs. Conf. ^d
a	Me	Et	91	38	S
b	Me	<i>i</i> -Bu	80	44	S
c	Me	<i>i</i> -Pr	94	66	S
d	Ph	Me	96	90	S
e	Ph	Et	87	62	S
f	Ph	<i>i</i> -Pr	93	10	S
g	Ph	<i>t</i> -Bu	45	7	R
h	α-tetralone		89	24	S

^a[2]:[1]:[BH₃-THF]=1:1:1. ^bGC yields. ^cDetermined by capillary GC analyses of MTPA amides of **3**. ^dThe absolute configurations of the amine obtained were determined by comparison of the sign of rotation and the elution order of the MTPA amides of optically active authentic amines.

also proceeded smoothly to give the corresponding primary amines **3d-3f** and **3h** in 87-96% chemical yields within 24 h, whereas a hindered aromatic ketoxime derivative, pivalophenone *O*-trimethylsilyl ether **2g**, was reduced very slowly to give a 45% yield in 48 h. When steric size of R in PhCR=NOTMS was varied from Me→Et→*i*-Pr→*t*-Bu, the optical yields of the corresponding amines obtained decreased remarkably, such as 90% ee for **2d**, 62% ee for **2e**, 10% ee for **2f**, and 7% ee for **2g**. The optical yield obtained from **2h** was 24% ee. With the exception of **3g**, all of the products amines obtained are consistently enriched in S enantiomers. In contrast, the absolute configuration of **3g** is reversed to R enantiomer. The reason for the variation of optical inductions by the increase of steric size is not fully understood, but it seems to be attributable to the geometry of ketoxime derivatives.³ The results are summarized in Table 1. The following procedure is representative. To a mixture of **1** (2 mmol) and BH₃-THF (2 mmol) in THF was added **2d** (2 mmol) and *n*-dodecane (2 mmol) as an internal standard for GC analysis. After stirring for 24 h at room temperature, the reaction mixture was hydrolyzed by addition of *c*-HCl. GC analysis indicated the formation of **3d** in a 96% yield. THF was removed *in vacuo*. And then the residue was basified with *c*-NaOH and extracted with diethyl ether. The ether extract was dried over anhydrous K₂CO₃ and concentrated. The product amine **3d** was isolated by distillation under reduced pressure. This was converted into its MTPA amide by treatment of MTPA chloride.⁴ Capillary GC analysis of the diastereoisomeric ratio of the amide shows 90% ee, S.

On the other hand, to examine the effect of *O*-substituents of ketoxime for optical induction in this reaction, the asymmetric borane reductions of acetophenone oxime **4** and its derivatives such as acetophenone oxime *O*-methyl ether **5**, acetophenone oxime *O*-benzyl ether **6** and acetophenone

oxime *O*-acetate **7**, were carried out under the same condition as described above. The reductions proceeded smoothly to afford the corresponding amine **3d**. However, the optical yields of **3d** obtained were lower than 90% ee of *O*-trimethylsilyl ether derivative **2d**, such as 7% ee for **4**, 58% ee for **5**, 70% ee for **6** and 32% ee for **7**. The absolute configuration of **3d** obtained showed S enantiomer except for **7**. The reason for exhibiting R configuration in **7** is unclear.



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- In this reaction, the production of amines **3** with S configuration is presumably due to *re* side attack of hydride to *sp*² carbon of antiisomers of ketoxime ethers **2** (Figure 1). Low optical induction and R configuration of **3g** might be attributed to bulkiness of *tert*-butyl group producing mixture of *syn-anti* isomers in **2g**. It is reported that the asymmetric reduction of *anti* isomer of oxime ethers provides (S)-amines: see ref. 1g.

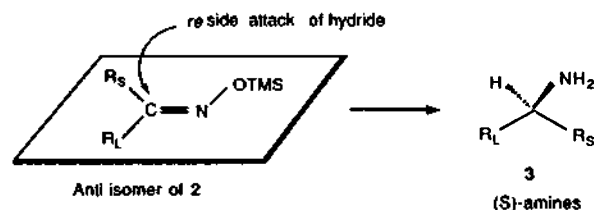


Figure 1.

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