

SYNLETT Spotlight 57

Bu₂BOTf: A Powerful Tool in Stereoselective Synthesis

Compiled by Thilo J. Heckrodt



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

Thilo J. Heckrodt was born in 1976; he started to study chemistry in 1997 at the Free University of Berlin, Germany, where he completed his diploma thesis under the supervision of Prof. H.-U. Reissig. After completion of his diploma in 2001, he joined the research group of Prof. J. Mulzer, University of Vienna, Austria and is currently working towards his PhD. He is recipient of a Kekulé fellowship; his research interest is focused on the asymmetric total synthesis of stereochemically complex natural products.

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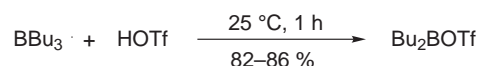
Introduction

In 1980 Mukaiyama et al. published the first synthesis of di-*n*-butylboryl trifluoromethanesulfonate (Bu₂BOTf) and demonstrated that this Lewis acid is particularly suitable for the generation of vinyloxyboranes (boron enolates).¹ In the presence of a sterically hindered amine base (typically *i*-Pr₂EtN, Et₃N or 2,6-lutidine) and Bu₂BOTf vinyloxyboranes are conveniently prepared from active methylene-carbonyl containing compounds. The boron enolates turned out to be efficient intermediates for addition to carbonyls in cross-aldol reactions. With unsymmetrical ketones, use of Bu₂BOTf and *i*-PrEt₂N results in the regioselective formation of the vinyloxyborane at the least hindered carbon. The relative stereochemistry of the new chiral centers formed in the aldol product is a direct consequence of vinyloxyborane enolate geometry with *Z*-enolates affording the 2,3-*syn* aldol products and the *E*-vinyloxyboranes leading to the 2,3-*trans* isomers. With Bu₂BOTf a remarkably high stereoselectivity towards the *Z*-enolate is observed which results in highly *syn*-selective aldol reactions. Probably the greatest utility of this reagent has been in the stereoselective formation of vinyloxyboranes attached to a chiral auxiliary.² These are typified by

the chiral oxazolidinones derived from α -amino alcohols initially developed by Evans. This modern methodology is a powerful tool for the highly enantioselective construction of two new chiral centers in an aldol addition under recycling of the auxiliary. Vinyloxyboranes also react with electrophiles other than aldehydes, furthermore it is possible to generate boryl azaenolates with Bu₂BOTf. In the area of macrolactonization Bu₂BOTf has also been used.

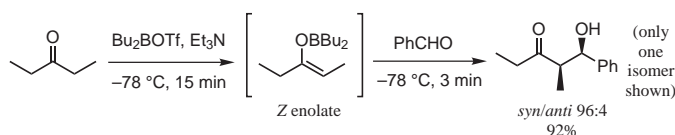
Preparation of Bu₂BOTf

Bu₂BOTf is commercially available as a 1 M solution in CH₂Cl₂ or Et₂O. However it is recommended that the reagent is freshly prepared and used pure, as the quality of stored Bu₂BOTf decreases quite rapidly due to its high moisture and air sensitivity. Bu₂BOTf is synthesised from tri-*n*-butylborane and trifluoromethanesulfonic acid; the product is isolated by vacuum distillation under argon.^{1,3}

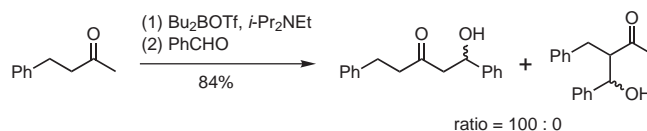


Abstracts

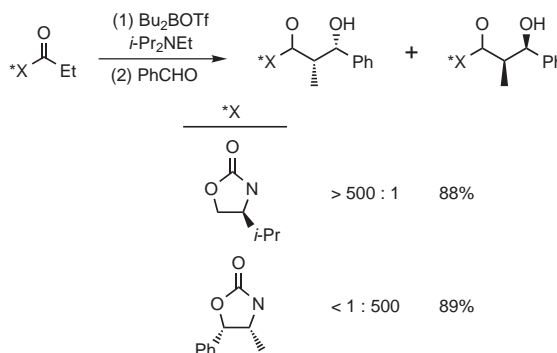
(A) In early applications Bu₂BOTf was used to form boron enolates, which undergo diastereoselective aldol additions (*syn*). The stereoselectivity was found to be dependent on the temperature; the reaction at lower temperature (−78 °C) gave rise to a high stereoselectivity, a fairly good selectivity was observed at room temperature.¹



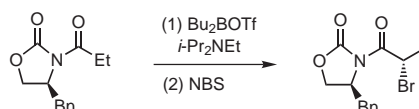
(B) Control of the regiochemistry is possible. Only one of the regioisomers of cross-aldols is produced without being accompanied by a detectable amount of the other regioisomers.¹



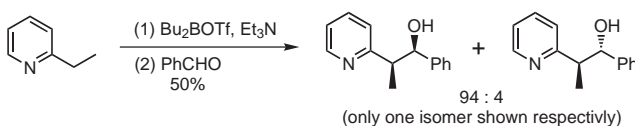
(C) The use of a chiral auxiliary attached to the vinyloxyboranes makes it possible to control the absolute stereochemistry of the new chiral centers formed in the aldol process. This chemistry initially developed by Evans,^{2,4} is nowadays an important tool in stereoselective synthesis and has found wide application in the field of total synthesis.



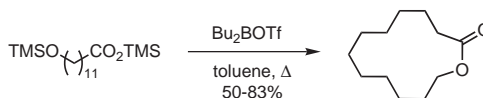
(D) Vinyloxyboranes also react with electrophiles other than aldehydes. For example chiral bromides can be synthesised stereoselectively using *N*-bromosuccinimide as the electrophile source.⁵



(E) The formation of boryl azaenolates proceeds smoothly, and they condense with various substituted benzaldehydes to yield β -hydroxy nitrile products.⁶ For instance 2-ethylpyridine gives predominantly the 2,3-*syn* aldol product.⁷



(F) In the presence of 1 equivalent of Bu₂BOTf trimethylsilyl ω -trimethylsilyloxycarboxylates cyclize to the corresponding macrolides.⁸



References

- (1) Inoue, T.; Mukaiyama, T. *Bull. Chem. Soc. Jpn.* **1980**, *53*, 174.
- (2) Evans, D. A.; Bartroli, J.; Shih, T. L. *J. Am. Chem. Soc.* **1981**, *103*, 2127.
- (3) Paquette, L. A. *Encyclopedia of Reagents for Organic Synthesis*, Vol 3; John Wiley & Sons: New York, **1995**, 1596.
- (4) Evans, D. A.; Gage, J. R. *Org. Synth.* **1990**, *68*, 83.
- (5) Evans, D. A.; Ellman, J. A.; Dorow, R. L. *Tetrahedron Lett.* **1987**, *28*, 1123.
- (6) Hamana, H.; Sugasawa, T. *Chem. Lett.* **1982**, 1401.
- (7) Hamana, H.; Sugasawa, T. *Chem. Lett.* **1984**, 1591.
- (8) Taniguchi, N.; Kinoshita, H.; Inomata, K.; Kotake, H. *Chem. Lett.* **1984**, 1347.