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Novel Synthesis of (*E*)-*gem*-Dimetalloalkenes Containing Boron and Tin and Their Conversion into Carboxylic Acids

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Asian Journal of Organic & Medicinal Chemistry

Volume: 2 Year: 2017
Issue: 2 Month: April–June
pp: 78–80
DOI: https://doi.org/10.14233/ajomc.2017.AJOMC-P40

Received: 8 December 2016
Accepted: 1 May 2017
Published: 3 July 2017

ABSTRACT

A convenient, novel synthesis of (*E*)-*gem*-dimetalloakenes containing boron and tin based on *Z*-1-bromo-1-alkenylboronate esters is developed. α-Bromo-(*Z*)-1-alkenylboronate esters readily available from literature procedures smoothly undergo a reaction with freshly generated trimethylstannyllithium in hexamethylphosphoramide (HMPA) from reacting hexamethylditin with methyllithium at -78 °C to provide the corresponding tetracoordinated boron complexes. These boron complexes undergo intramolecular nucleophilic substitution reaction to provide the corresponding (*E*)-1-alkenylboronate esters containing trimethylstannyl moiety. These intermediates are isolated in good yields (70-82 %) and are characterized by the spectral data (^{1}H NMR and ^{13}C NMR). Upon oxidation with hydrogen peroxide and sodium hydroxide followed by acidification the corresponding carboxylic acids are obtained in good yields (72-85 %).

KEYWORDS

gem-Dimetalloalkanes, Trimethylstannyllithium, Hexamethylditin, Alkenylboronate, Methyllithium.

INTRODUCTION

The *gem*-dimetalloalkenes [1] are important intermediates in organic synthesis. In view of their synthetic importance, it was desirable to have a general, convenient methodology for the synthesis of stereo-defined *gem*-dimetalloalkenes containing boron and tin especially from the readily available organoborane reagents.

In a previous study, a stereoselective preparation of the (*Z*)-1-bromo-1-alkenylboronate esters *via* the hydroboration of 1-bromo-1-alkynes followed by treatment with 1,3-propane diol has been reported [2]. It should be noted that these α-halo-(*Z*)-1-alkyenylboronate esters are known to undergo intramolecular nucleophilic substitution reactions [3-5] with nucleophiles such as hydrides [6], Grignard reagents [7], organolithium reagents, [7] allylmagnesium bromide [8], trimethylsilylmethyllithium [9] and trimethylsilyllithium [10].

In this report, we reacted α-bromo-(*Z*)-1-hexenylboronate esters with a nucleophilic reagent such as freshly prepared trimethylstannyllithium in hexamethylphosphoramide followed by oxidation with alkaline hydrogen peroxide (eq. 1). Consequently, we describe a facile general synthesis of (*E*)-*gem*-

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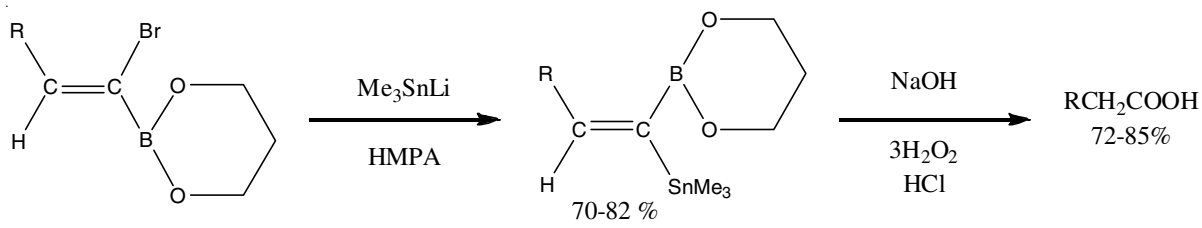

Equation 1

dimetalloalkenes containing boron and tin and their oxidation to carboxylic acids based on versatile intermediates such as α-bromo-(*Z*)-1-alkenylboronate esters.

EXPERIMENTAL

All handling of air- and moisture-sensitive compounds was carried out under a purified nitrogen atmosphere. All glassware used was dried in an oven at 160 °C, assembled hot and cooled with a stream of nitrogen. All of the compounds prepared were characterized by spectral data. IR spectra were recorded as neat liquids. ^{1}H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$ without TMS as an internal standard on a 300 MHz Jeol NMR spectrophotometer. The yields reported in all cases are of pure compounds unless otherwise mentioned.

All chemicals, used for the experimental procedure, were purchased from the Aldrich Chemical Company. The 1-trimethylstannyl-1-alkynes were prepared *via* the deprotonation of the appropriate 1-alkynes followed by treatment with trimethyltin chloride.

Dried solvents such as *n*-pentane and tetrahydrofuran were used and obtained from the Aldrich Chemical Company.

Preparation of *n*-hexanoic acid from the (*E*)-2-(1-trimethylstannyl-1-hexenyl)-1,3,2-dioxaborinane is representative: To a solution of (*E*)-2-(1-trimethylstannyl-1-hexenyl)-1,3,2-dioxaborinane (10 mmol, 2.85 g) in tetrahydrofuran (10 mL) was added 5 mL of methanol. It was then cooled to 0 °C and sodium hydroxide (3 M, 5 mL) was added slowly followed by 30 % hydrogen peroxide (25 mmol, 2.5 mL). The reaction mixture was allowed to settle to room temperature and the stirring was continued for 4 h at room temperature. Also, 5 mL of 3 M sodium hydroxide was added. The reaction mixture was washed twice with ether (2 × 30 mL). Acidification of the aqueous phase was performed with concentrated hydrochloric acid. It was then extracted with ether (2 × 30 mL) followed by the removal of ether provided *n*-hexanoic acid in 78 % (0.90 g) isolated yield. IR, ^{1}H NMR and ^{13}C NMR spectral data characterized the compound. IR (neat): < 2926, and 1718 cm^{-1}; ^{1}H NMR ($CDCl_3$/without TMS): * 0.8 (3H, *m*), 1.28-1.57 (6H, *m*), 2.30 (2H, *m*) and 11.75 (1H, *s*) ppm; ^{13}C NMR ($CDCl_3$/without TMS): * 13.79, 22.31, 24.37, 31.24, 34.11 and 180.74 ppm.

RESULTS AND DISCUSSION

The required starting materials such as 1-bromo-1-alkynes and α-bromo-(*Z*)-1- alkenylboronate esters are prepared using literature procedures [2]. In a typical experiment, α-bromo-(*Z*)-1-hexenylboronate ester was reacted with trimethylstannyllithium [11] in hexamethylphosphoramide (easily generated by reacting hexamethylditin with methyllithium at 0 °C for 0.5 h) at -78 °C under an inert atmosphere and the reaction mixture was stirred at -78 °C for 2 h followed by stirring overnight at room temperature. The resulting product was isolated and purified by column chromatography over silica gel (entry 1, Table-1, 82 %). Representative *gem*-dimetalloalkenes containing boron and tin were prepared using this procedure (Table-1). It was then subjected to oxidation using hydrogen peroxide and sodium hydroxide in tetrahydrofuran at room temperature for 4 h. After acidic workup, the reaction provided the corresponding carboxylic acids in good yields (72-85 %).

TABLE-1
STEREOSELECTIVE SYNTHESIS OF (*E*)-*gem*-DIMETALLOALKENES CONTAINING BORON AND TIN

Entry[a]	Eqn. 1, R =	Isolated yield[b,c] (%)
1	*n*-C_4H_9	85
2	*n*-C_5H_{11}	78
3	*n*-C_6H_{13}	80
4	*n*-$Cl(CH_2)_3$	72
5	-$C(CH_3)_3$	76
6	-$CH_2CH_2CH(CH_3)_2$	74
7	–CH_2CH_2Ph	75

[a]All of the compounds were oxidized with sodium hydroxide and hydrogen peroxide to the corresponding carboxylic acids in > 72 % isolated yields. They were characterized by spectral data (IR, PMR, and CMR). [b]All of the reactions were carried out on a 5 mmol scale. The yields were based on the corresponding α-bromo-(*Z*)-1-alkenylboronate esters. [c]All of the compounds were isolated by column chromatography over silica gel and were characterized by IR and NMR spectral data. The stereochemical purities [Ref. 12] of these intermediates were confirmed by PMR and CMR spectral data.

Presumably, the starting α-bromo-(*Z*)-1-alkenylboronate ester could form an "ate" complex as a result of a reaction with trimethylstannyllithium. This would further undergo an anionotropic rearrangement involving the migration of the trimethylstannyl group from boron to the adjacent alkenyl carbon with inversion of configuration to provide (*E*)-trisubstituted boron intermediate containing trimethylstannyl moiety, the oxidation of which would provide the carboxylic acids. Oxidation studies to provide alkyl trimethylstannyl ketones failed in our laboratory.

Conclusion

In conclusion, we have developed a novel synthetic route for the preparation of carboxylic acid based on the reactions of trimethylstannyllithium with α-bromo-(*Z*)-1-alkenylboronate esters followed by oxidation. These *gem*-dimetalloalkenes containing boron and tin intermediates have been isolated and characterized for the first time by spectral data. The representative synthetic applications of these (*E*)-trisubstituted organo-

borane intermediates containing trimethylstannyl moiety are currently underway. Althogh this is a novel stanyl substituted intermediate, similar reports of 1-stannyl-1-boryl-2-alkyl-alkenes are reported in literature [13].

ACKNOWLEDGEMENTS

The authors are highly grateful to Robert A. Welch, Foundation of Texas under the grant number BG-1387 and to the National Institutes of Health-MBRS program under the grant number NIH NIGMS 2S06GM08038-32 for their generous financial support to undertake this project.

REFERENCES

1. N.G. Bhat, A. Tamm and A. Gorena, *Synlett*, 297 (2004); https://doi.org/10.1055/s-2004-815399.
2. H.C. Brown, N.G. Bhat and V. Somayaji, *Organometallics*, **2**, 1311 (1983); https://doi.org/10.1021/om50004a008.
3. D.S. Matteson and D. Majumdar, *Organometallics*, **2**, 1529 (1983); https://doi.org/10.1021/om50005a008.
4. D.J. Tsai, P.K. Jesthi and D.S. Matteson, *Organometallics*, **2**, 1543 (1983); https://doi.org/10.1021/om50005a010.
5. H.C. Brown, N.R. De Lue, Y. Yamamoto, K. Maruyama, T. Kasahara, S. Murahashi and A. Sonoda, *J. Org. Chem.*, **42**, 4088 (1977); https://doi.org/10.1021/jo00445a022.
6. M.W. Rathke, E. Chao and G. Wu, *J. Organomet. Chem.*, **122**, 145 (1976); https://doi.org/10.1016/S0022-328X(00)80606-3.
7. H.C. Brown, T. Imai, *Organometallics*, **3**, 1392 (1984); https://doi.org/10.1021/om00087a013.
8. H.C. Brown, T. Imai and N.G. Bhat, *J. Org. Chem.*, **51**, 5277 (1986); https://doi.org/10.1021/jo00376a042.
9. H.C. Brown and R. Soundararajan, *Tetrahedron Lett.*, **35**, 6963 (1994); https://doi.org/10.1016/0040-4039(94)88199-5.
10. N.G. Bhat, C. Martinez and J. De Los Santos, *Tetrahedron Lett.*, **41**, 6541 (2000); https://doi.org/10.1016/S0040-4039(00)01088-1.
11. W.C. Still, *J. Org. Chem.*, **41**, 3063 (1976); https://doi.org/10.1021/jo00880a044.
12. J.D. Roberts, D.E. Dorman and M. Jautelat, *J. Org. Chem.*, **36**, 2757 (1971); https://doi.org/10.1021/jo00818a007.
13. B. Wrackmeyer, O.L. Tok, E. Klimkina and Y.N. Bubnov, *Inorg. Chim. Acta*, **300-302**, 169 (2000); https://doi.org/10.1016/S0020-1693(99)00551-4.