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# Reaction of [(*Z*)-1-bromo-1-alkenyl]dialkylboranes with *N*-halogeno compound in THF–DMF: a novel synthesis of 1,2-disubstituted (*E*)-vinyl bromides

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**Abstract**

DMF-induced reaction of [(*Z*)-1-bromo-1-alkenyl]dialkylboranes with an *N*-halogeno compound results in 1,2-migration of an alkyl group from the dialkylboryl group to the α-carbon atom without elimination of the bromine atom, followed by β-elimination to provide 1,2-disubstituted (*E*)-vinyl bromides stereoselectively in good yields.


*Keywords:* [(*Z*)-1-bromo-1-alkenyl]dialkylboranes; DMF; *N*-halogeno compound; 1,2-disubstituted (*E*)-vinyl bromides; 1,2-migration.

Alkenylboranes are known to be quite useful intermediates in organic synthesis, especially in the case of carbon–carbon bond formation such as the Zweifel-type reaction[1] and Suzuki–Miyaura coupling reaction.[2] Among various alkenylboranes, [(*Z*)-1-halo-1-alkenyl]dialkylboranes have been usually used as precursors of [(*Z*)-1-alkenyl]dialkylboranes[3] and internal (*E*)-alkenylboranes[4] which are unavailable via hydroboration of alkynes. Thus, the reaction of [(*Z*)-1-halo-1-alkenyl]dialkylboranes with nucleophiles, such as hydride[3] and methoxide,[4a] causes elimination of the halogen atom and simultaneous migration of the nucleophile or the alkyl group on the boron atom to the α-carbon atom with inversion of configuration via the corresponding ate-complexes. However, there are very few reports of organic synthesis using [(*Z*)-1-halo-1-alkenyl]dialkylboranes without elimination of the halogen atom.[4a,5] Very recently, we have reported that treatment of [(*Z*)-1-bromo-1-alkenyl]dialkylboranes (**1**) with DMSO, which would act as a nucleophilic activator, in a nonpolar solvent such as $ClCH_2CH_2Cl$ or $CCl_4$, gives 1,2-disubstituted (*E*)-vinyl bromides (**2**) stereoselectively.[6] We now report here a new and general access to **2** using DMF-induced reaction of **1** with an *N*-halogeno compound where DMF would play an important role as a polar solvent and the *N*-halogeno compound would act as an electrophilic promoter.

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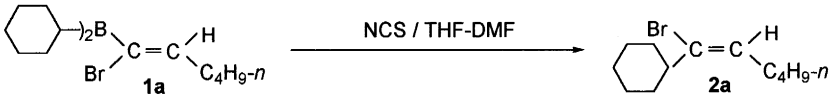
We chose [(*Z*)-1-bromo-1-hexenyl]dicyclohexylborane (**1a**), prepared by hydroboration of 1-bromo-1-hexyne with dicyclohexylborane, as a substrate and examined the reaction with *N*-halogeno compounds. When the reaction with *N*-chlorosuccinimide (NCS) was carried out in a mixed solvent of THF–DMF, the formation of (*E*)-1-bromo-1-cyclohexyl-1-hexene (**2a**)[7] was observed (Eq. (1)). The results performed under several reaction conditions are summarized in Table 1. The highest yield was obtained in the reaction carried out in THF–DMF (1:1) at −50°C to room temperature. Thus, the reaction of **1a** with 1.75 equiv. of NCS gave 84% yield of **2a** with high stereoselectivity (*E*:*Z*=98:2) (entry 4). It should be noted that in the absence of DMF the reaction gave only a trace amount of **2a** (entry 1). Although the desired reaction also proceeded in the presence of other co-solvents under similar conditions (entries 8–10), DMF was superior to other co-solvents employed in terms of both yield and stereoselectivity (entry 3).




(1)

Table 1
Effects of co-solvent and amount of NCS[a]

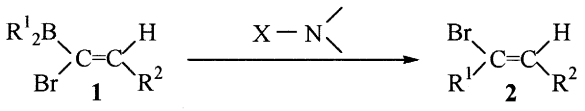
| Entry | Co-solvent | Ratio (v/v) THF : co-solvent | NCS (equiv to **1a**) | Yield of **2a** (%)[b] | Isomer[c] *E* : *Z* |
|---|---|---|---|---|---|
| 1 | none | 1 : 0 | 1.0 | trace | —— |
| 2 | DMF | 1 : 1 | | 52 | 99 : 1 |
| 3 | | | 1.5 | 72 | 98 : 2 |
| 4 | | | 1.75 | 84 | 98 : 2 |
| 5 | | | 2.0 | 80 | 98 : 2 |
| 6 | | 1 : 0.5 | 1.75 | 80 | 97 : 3 |
| 7 | | 1 : 2 | | 77 | 99 : 1 |
| 8 | DMI | 1 : 1 | 1.5 | 43 | 93 : 7 |
| 9 | DMA | | | 59 | 92 : 8 |
| 10 | NMP | | | 65 | 94 : 6 |

[a] Reactions were carried out at −50 °C to room temperature. [b] GLC yields based on 1-bromo-1-hexyne employed. [c] Determined by GLC analysis.

The reaction of a variety of **1** with an *N*-halogeno compound was carried out in the presence of DMF, and the results are summarized in Table 2. The present reaction could be applied to various alkyl groups ($R^1$) ranging from the relatively hindered 1,2-dimethylpropyl group to the less hindered hexyl group, and is tolerant of functional groups such as chloro, ether, ester and silyl function (entries 4–7 and 15). The yields of **2** were improved by making a choice of the *N*-halogeno compound, for example, using *N*-bromosuccinimide (NBS) instead of NCS (entry 3) and *N*-bromoacetamide (NBA) instead of NBS (entries 6 and 9). In the case of **1j**, however, changing NCS for NBA did not lead to a significant increase in yield. In all cases examined, 1,2-disubstituted (*E*)-vinyl bromides (**2**) were formed in a highly stereoselective fashion and obtained in good yields. The reaction of **1d**, **1e** and **1f** with NBA proceeded smoothly to give the corresponding products **2d**, **2e**[8] and **2f**, respectively (entries 6, 7 and 9). On the other hand, the reaction of **1d** and **1e** with DMSO gave **2d** and **2e** in poor yields, respectively, and the reaction of **1f** with DMSO could hardly proceed under the conditions described in Ref. 6. The result of

the former reaction is due to the decomposition of **1d** and **1e** caused by removal of THF, and in the latter reaction is probably due to the steric hindrance between the 1,2-dimethylpropyl group on the boron atom and DMSO.[9] The present reaction thus overcame the disadvantages of the protocol using DMSO.

Table 2
DMF-induced reaction of [(*Z*)-1-bromo-1-alkenyl]dialkylboranes with *N*-halogeno compound[a]

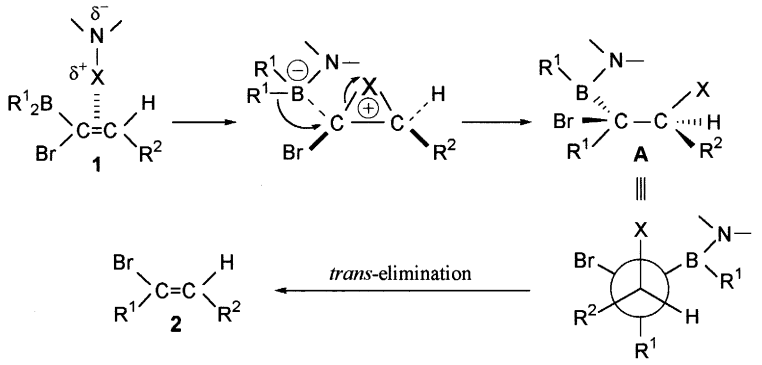


| Entry | $R^1$ | $R^2$ | X–N< [b] | Product | Yield (%)[c] |
|---|---|---|---|---|---|
| 1 | *c*-$C_6H_{11}$ | *n*-$C_4H_9$ | NCS | **2a** | 82 |
| 2 | *c*-$C_6H_{11}$ | $C_6H_5$ | NCS | **2b** | (41) |
| 3 | | | NBS | **2b** | 77 |
| 4 | *c*-$C_6H_{11}$ | $(CH_2)_3Cl$ | NCS | **2c** | 74 |
| 5 | *c*-$C_6H_{11}$ | $CH_2OCH_3$ | NBS | **2d** | (41) |
| 6 | | | NBA | **2d** | 82 |
| 7 | *c*-$C_6H_{11}$ | $CH_2OAc$ | NBA | **2e** | 88 |
| 8 | $(CH_3)_2CHCHCH_3$ | *n*-$C_4H_9$ | NBS | **2f** | (54) |
| 9 | | | NBA | **2f** | 80 |
| 10 | $(CH_3)_2CHCHCH_3$ | $C_6H_5$ | NBA | **2g** | 58 |
| 11 | *n*-$C_6H_{13}$ | *n*-$C_4H_9$ | NCS[d] | **2h** | 71 |
| 12 | *n*-$C_6H_{13}$ | $C_6H_5$ | NBA | **2i** | 75 |
| 13 | $C_6H_5CH(CH_3)CH_2$ | *n*-$C_4H_9$ | NCS[d] | **2j** | 65 |
| 14 | | | NBA | **2j** | (72) |
| 15 | $(CH_3)_3SiCH_2CH_2CH_2$ | *n*-$C_4H_9$ | NCS[d] | **2k** | 65 |
| 16 | *c*-$C_5H_9$ | *n*-$C_4H_9$ | NCS[d] | **2l** | 71 |
| 17 |  | *n*-$C_4H_9$ | NCS[d] | **2m** | 63[e] |

[a] All reactions were carried out in THF-DMF (1 : 1) at −50 °C to room temperature.
[b] Unless otherwise stated, 1.75 equiv of NCS, 3.0 equiv of NBS, or 2.5 equiv of NBA was used. [c] Isolated yields based on 1-bromo-1-alkyne employed. Isomeric purities are >99—98%. GLC yields are given in parentheses. [d] 2.25 equiv of NCS was used.
[e] Isomeric purity is 95%.

We envisage the reaction mechanism for the formation of **2** as shown in Scheme 1. DMF probably plays an important role in the initial stage of the present reaction. The reaction appears to be initiated by the electrophilic attack of the *N*-halogeno compound. It is assumed that the formation of a halonium ion across the carbon–carbon double bond followed by 1,2-migration of an alkyl group from the boron atom

to the α-carbon atom would take place to form intermediate **A**, which would undergo *trans*-elimination of the alkylaminoboryl and halogeno groups to yield **2**.




Scheme 1. Proposed mechanism for the formation of disubstituted (*E*)-vinyl bromides

In conclusion, we have demonstrated for the first time that DMF induces the reaction of [(*Z*)-1-bromo-1-alkenyl]dialkylboranes (**1**) with an *N*-halogeno compound to provide 1,2-disubstituted (*E*)-vinyl bromides (**2**), where a wide range of alkyl substituents are permitted to participate in the conversion of **1** into **2**, as compared to the reaction with DMSO.

## References


1. For example, see: (a) Pelter, A.; Smith, K.; Brown, H. C. In *Borane Reagents*; Academic: London, 1988. (b) Matteson, D. S. In *Stereodirected Synthesis with Organoboranes*; Springer: Berlin, 1995.
2. For example, see: (a) Miyaura, N.; Suzuki, A. *Chem. Rev*. **1995**, *95*, 2457–2483. (b) Suzuki, A. In *Metal-Catalyzed Cross-Coupling Reactions*; Diederich, F.; Stang, P. J., Eds.; Wiley-VCH: Weinheim, 1998; pp. 49–97.
3. (a) Negishi, E.; Williams, R. M.; Lew, G.; Yoshida, T. *J. Organomet. Chem*. **1975**, *92*, C4–C6. (b) Campbell Jr., J. B.; Molander, G. *J. Organomet. Chem*. **1978**, *156*, 71–79.
4. (a) Zweifel, G.; Arzoumanian, H. *J. Am. Chem. Soc*. **1967**, *89*, 5086–5088. (b) Negishi, E.; Yoshida, T. *J. Chem. Soc., Chem. Commun*. **1973**, 606–607. (c) Arase, A.; Hoshi, M.; Masuda, Y. *Bull. Chem. Soc. Jpn*. **1984**, *57*, 209–213. (d) Hoshi, M.; Masuda, Y.; Arase, A. *Bull. Chem. Soc. Jpn*. **1985**, *58*, 1683–1689. (e) Brown, H. C.; Basavaiah, D.; Kulkarni, S. U.; Lee, H. D.; Negishi, E.; Katz, J.-J. *J. Org. Chem*. **1986**, *51*, 5270–5276. (f) Brown, H. C.; Imai, T.; Bhat, N. G. *J. Org. Chem*. **1986**, *51*, 5277–5282.
5. (a) Masuda, Y.; Arase, A.; Suzuki, A. *Chem. Lett*. **1978**, 665–668. (b) Masuda, Y.; Arase, A.; Suzuki, A. *Bull. Chem. Soc. Jpn*. **1980**, *53*, 1652–1655. (c) Brown, H. C.; Blue, C. D.; Nelson, D. J.; Bhat, N. G. *J. Org. Chem*. **1989**, *54*, 6064–6067.
6. Hoshi, M.; Tanaka, H.; Shirakawa, K.; Arase, A. *Chem. Commun*. **1999**, 627–628.
7. The spectral data of the product **2a** were consistent with those reported in Ref. 6.
8. To a solution of **1e** (4 mmol) in THF was added dry DMF (10 ml) at 0°C under argon atmosphere. The mixture was stirred at the same temperature for 0.5 h and cooled to −50°C. To this mixture was added NBA (1.379 g, 10 mmol), and then the reaction mixture was allowed to warm to room temperature without removing the bath and was stirred overnight. The resulting mixture was treated with $NaBO_3 \cdot 4H_2O$ (1.23 g, 8 mmol) and $H_2O$ (2.67 ml) at room temperature with vigorous stirring for 2 h. Water (20 ml) was added, and the organic products were extracted with *n*-hexane. The organic layer was separated, dried with $Na_2SO_4$ and concentrated in vacuo. The residue was purified by column chromatography on silica gel (*n*-hexane:$CH_2Cl_2$=9:1) to give **2e** (0.918 g, 88% yield) as a colorless liquid. Compound **2e**: IR (neat) 2931, 2856, 1743, 1639, 1448, 1379, 1363, 1226, 1122, 1026, 893, 798 $cm^{-1}$; $^1H$ NMR (500 MHz, $CDCl_3$) $\delta$ 1.18 (dtt, *J*=12.8, 12.8, 3.7 Hz, 1H), 1.34 (dtt, *J*=12.8, 12.8, 3.7 Hz, 2H), 1.48–1.61 (m, 4H), 1.65–1.73 (m, 1H), 1.76–1.83 (m, 2H), 2.06 (s, 3H), 2.52 (tt, *J*=10.7, 4.0 Hz, 1H), 4.57 (d, *J*=7.3 Hz, 2H), 5.97 (t, *J*=7.3 Hz, 1H); $^{13}C$ NMR (125 MHz, $CDCl_3$) $\delta$ 20.86, 25.52, 25.60 (2C), 31.61 (2C), 42.36, 60.55, 124.56, 140.11, 170.70; MS *m/z* (EI) 181 ($M^+-79$ or 81, 22%), 139 (100), 121 (21), 93 (15), 79 (25), 67 (19), 44 (90), 42 (15).
9. Hoshi, M.; Shirakawa, K., unpublished result.