(*E*)-β,γ-Unsaturated Amides from (*E*)-9-Alkenyl-9-borabicyclo[3.3.1]nonane and *N,N*-Dialkyl(dimethylsulfuranylidene)acetamide

Min-Zhi Deng,* Nan-Sheng Li and Yao-Zeng Huang*

Laboratory of Organometallic Chemistry, Shanghai Institute of Organic Chemistry, Academia Sinica, 345 Lingling Lu, Shanghai 200032, China

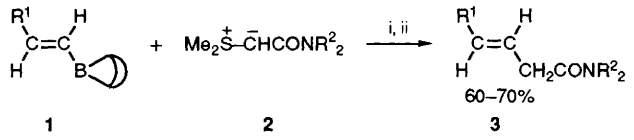
A facile route for the stereocontrolled synthesis of (*E*)-β,γ-unsaturated amides by the reaction of stereodefined 9-alkenyl-9-borabicyclo[3.3.1]nonane with *N,N*-dialkyl(dimethylsulfuranylidene)acetamide is described.

β,γ-Unsaturated amides are versatile synthetic intermediates. For example, reduction of β,γ-unsaturated amides with $LiAlH_4$ in diethyl ether gives homoallylamines in good yields.[1] There are several methods for the preparation of β,γ-unsaturated amides from allyl amine,[1] allyl phosphate[2] or allyl alcohol[3] reported in the literature. But all of them are from allyl compounds and result in a one carbon increase. In addition, some of them are not stereodefined and others require the use of valuable noble metal catalysts and carbon monoxide.

To the best of our knowledge, there is no method for the preparation of β,γ-unsaturated amides from alkenyl compounds by a two carbon increase in the literature. Brown *et al.* reported that (*E*)-β,γ-unsaturated esters, ketones, nitriles could be prepared from (*E*)-9-alkenyl-9-borabicyclo[3.3.1]-nonane **1** and ethyl α-bromoacetate, α-bromoketone or α-chloroacetonitrile under the influence of the special hindered base, potassium 2,6-di-*tert*-butylphenolate.[4] However, we found that (*E*)-β,γ-unsaturated amides could not be obtained from **1** and α-bromoacetamide by Brown's procedure.[4] Recently, we reported that (*E*)-β,γ-unsaturated esters could be prepared from **1** and ethyl (dimethylsulfuranylidene)acetate in good yields.[5] This method can be applied not only to terminal but also internal 9-alkenyl-9-borabicyclo[3.3.1]-nonane compounds.

In this communication, we report the results of the reaction of stereodefined **1** with *N,N*-dialkyl(dimethylsulfuranylidene)acetamide. This is the first example of the synthesis of (*E*)-β,γ-unsaturated amides from alkenyl compounds by a two carbon increase.

The reaction is simple. *N,N*-Dialkyl-α-sulfonium-substituted amides can be easily prepared by direct reaction of dimethyl sulfide and *N,N*-dialkyl-α-bromoacetamides.[6] The stereodefined compounds **1** can be easily obtained by the hydroboration of various alkynes with 9-borabicyclo[3.3.1]-nonane, (9-BBN) in tetrahydrofuran (THF).[7] The stereo-



Scheme 1 *Reagents and conditions*: i, THF, room temp., 20 h; ii, H_2O_2–OAc^-, 0 °C–room temp., 1 h

Table 1 *N,N*-Dialkyl-(*E*)-β,γ-unsaturated amides prepared

Entry	Product[a]	R^1	R^2	Yield (%)[b]
1	**3a**	Pr^n	Et	60
2	**3b**	Pr^n	Pr^i	60
3	**3c**	Bu^n	Et	61
4	**3d**	Bu^n	Pr^i	61
5	**3e**	n-Pent	Et	66
6	**3f**	n-Pent	Pr^i	70
7	**3g**	n-Hex	Et	64
8	**3h**	n-Hex	Pr^i	65
9	**3i**	n-Oct	Et	62
10	**3j**	n-Oct	Pr^i	61
11	**3k**	Ph	Et	69
12	**3l**	Ph	Pr^i	67

[a] All products are in agreement with the IR, ^1H NMR, mass and high resolution mass spectroscopy data. [b] Isolated yields based on 9-BBN (2.5 mmol scale).

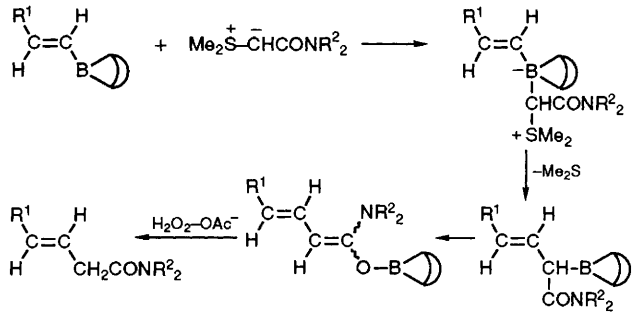
defined derivatives **1** generated *in situ*, readily react with *N,N*-dialkyl(dimethylsulfuranylidene)acetamide, which is prepared from *N,N*-dialkyl-α-sulfonium-substituted amide and sodium hydride at 0 °C in THF. The reaction mixture is then oxidized by H_2O_2–OAc^-, giving (*E*)-β,γ-unsaturated amides in 60–70% yields as shown in Scheme 1.

The reactions of various 9-alkenyl-9-BBNs with *N,N*-dialkyl(dimethylsulfuranylidene)acetamide were studied and the results are shown in Table 1. From Table 1, the highly stereoselective formation of *N,N*-dialkyl-(*E*)-β,γ-unsaturated amides in high yields indciates that the preferential migration of the alkenyl moiety from boron to the α-carbon of *N,N*-dialkyl(dimethylsulfuranylidene)acetamide occurs with complete retention of configuration. The mechanism may be depicted as shown in Scheme 2.

Although internal 9-alkenyl-9-BBN, which is obtained by the hydroboration of internal alkyne, can react with ethyl (dimethylsulfuranylidene)acetate to give (*E*)-β,γ-unsaturated ester,[5] and terminal 9-alkenyl-9-BBN can react with *N,N*-dialkyl(dimethylsulfuranylidene)acetamide to give *N,N*-dialkyl-(*E*)-β,γ-unsaturated amide in good yield, unfortunately, the reaction of internal 9-alkenyl-9-BBN with *N,N*-dialkyl(dimethylsulfuranylidene)acetamide did not afford the corresponding *N,N*-dialkyl-(*E*)-β,γ-unsaturated amide under our conditions. This may be due to the large steric bulkiness of both internal 9-alkenyl-9-BBN and *N,N*-dialkyl(dimethylsulfuranylidene)acetamide which hinders the attack of *N,N*-dialkyl(dimethylsulfuranylidene)acetamide to internal 9-alkenyl-9-BBN.

Since both terminal 9-alkenyl-9-BBN and dialkyl(dimethylsulfuranylidene)acetamide are easily available, the reaction affords *N,N*-dialkyl-(*E*)-β,γ-unsaturated amide with high *E* stereoselectivity under mild conditions in moderate yield, therefore this method may be attractive for the synthesis of *N,N*-dialkyl-(*E*)-β,γ-unsaturated amides.

The preparation of *N,N*-diethyl-(*E*)-non-3-enamide is representative. To a solution of heptyne (0.6 g, 6.25 mmol) in THF (10 ml), 9-BBN (0.31 g, 2.5 mmol) was added at 0 °C under argon. The reaction mixture was stirred at room temp. for 3 h. In another dry flask, NaH (0.09 g, 80%, 3 mmol) was washed using dry hexane (2 ml) to remove the paraffin, then



Scheme 2

THF (10 ml) was added to it under argon. Into the mixture of NaH in THF, $(Me_2SCH_2CONEt_2)^+Br^-$[6] (0.77 g, 3 mmol) was added at 0 °C. The reaction mixture was stirred at 0 °C for 2 h, then the solution of 9-(*E*)-hept-1-enyl-9-BBN in THF was transferred and dropped into the solution of *N,N*-diethyl-(dimethylsulfuranylidene)acetamide in THF at 0 °C. The reaction mixture was left at room temp. for 20 h, then the mixture was oxidized using H_2O_2 (2 ml, 30%) and NaOAc (2 ml, 3 mol dm^{-3}) at 0 °C for 1 h, extracted with diethyl ether, and the ethereal solution was dried ($MgSO_4$). *N,N*-Diethyl-(*E*)-non-3-enamide (0.35 g, 66% yield) was isolated by silica chromatography, eluted with light petroleum–ethyl acetate (v:v, 3:2). The configuration of *N,N*-diethyl-(*E*)-non-3-enamide is confirmed by IR, ^1H NMR; the strong peak at ν_{max}: 970 cm^{-1} in IR and the coupling constant (*J* 15 Hz) of the two vinyl protons in the ^1H NMR spectrum, (C_6D_6, $SiMe_4$, 200 MHz) of this product clearly indicate that the compound is the *E* isomer.†

We are grateful to the National Natural Science Foundation of China and Academia Sinica for the financial support of this project.

Received, 16th September 1992; Com. 2/04976G

References

1 S.-I. Murahashi, Y. Imada and K. Nishimura, *J. Chem. Soc., Chem. Commun.*, 1988, 1578.
2 S.-I. Murahashi and Y. Imada, *Chem. Lett.*, 1985, 1477.
3 G. Buchi, M. Cushman and H. Wuest, *J. Am. Chem. Soc.*, 1974, **96**, 5563.
4 H. C. Brown, B. T. Cho and W. S. Park, *J. Org. Chem.*, 1986, **51**, 3398.
5 M.-Z. Deng, N.-S. Li and Y.-Z. Huang, *J. Org. Chem.*, 1992, **57**, 4017.
6 W. E. Weaver and W. M. Whaley, *J. Am. Chem. Soc.*, 1947, **69**, 515; A. S. Speziale, C. C. Tung, K. W. Ratts and A. Yao, *J. Am. Chem. Soc.*, 1965, **87**, 3460.
7 K. K. Wang, C. G. Scouten and H. C. Brown, *J. Am. Chem. Soc.*, 1982, **104**, 531; H. C. Brown, C. G. Scouten and R. J. Liotta, *J. Am. Chem. Soc.*, 1979, **101**, 96.

† ^1H NMR ($CDCl_3$, $SiMe_4$, 200 MHz): δ 0.80 (3H, t, *J* 7.0 Hz, Me), 1.10 [6H, m, $N(CMe)_2$], 1.23 (6H, m, 3 × CH_2), 1.98 (2H, m, CH_2–C=C), 3.00 (2H, d, *J* 4.0 Hz, CH_2C=O), 3.30 [4H, m, $N(CH_2C)_2$], 5.48 (2H, m, CH=CH).

^1H NMR (C_6D_6, $SiMe_4$, 200 MHz): δ 0.74 [3H, t, *J* 8.0 Hz, N(CMe)], 0.86 (3H, t, *J* 7.0 Hz, Me), 0.96 [3H, t, *J* 8.0 Hz, N(CMe)], 1.23 (6H, m, 3 × CH_2), 1.98 (2H, m, CH_2–C=C), 2.80 (2H, q, *J* 8.0 Hz, NCH_2), 2.89 (2H, d, *J* 7.0 Hz, CH_2C=O), 3.20 (2H, q, *J* 8.0 Hz, NCH_2), 5.46 (1H, dt, *J* 15.0, 7.0 Hz, CH=CCC=O), 5.72 (1H, dt, *J* 15.0, 7.0 Hz, C=CHCC=O).

MS, *m/z* (%): 212 (M + 1, 12), 211 (M^+, 12), 154 (16), 100 (20), 73 (100). IR (neat): ν_{max}/cm^{-1} 1640, 1460, 1380, 1360, 970. HRMS for $C_{13}H_{25}NO$, calc.: 211.1936; found: 211.1933.