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Reductive debromination of 1,2-bis(bromomethyl)arenes using tetrakis(dimethylamino)ethylene (TDAE)

Yutaka Nishiyama,* Hiroshi Kawabata, Akihiro Kobayashi,
Toshiki Nishino and Noboru Sonoda*

Department of Applied Chemistry, Faculty of Engineering, Kansai University, Suita, Osaka 564-8680, Japan

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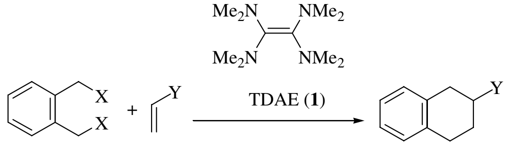
Abstract—A new method for the reductive debromination of 1,2-bis(bromomethyl)arenes has been developed. The treatment of 1,2-bis(bromomethyl)benzene with tetrakis(dimethylamino)ethylene (TDAE) (**1**) in the presence of olefins gave 1,2,3,4-tetrahydronaphthalenes in moderate to good yields.

Tetrakis(dimethylamino)ethylene (TDAE) (**1**) has an ionization potential of −0.61 V versus SCE,[1] and a reducing power comparable to that of zinc, which is often used as a reducing agent in organic synthesis. It is expected that **1** could be used as a reducing agent in organic synthesis; however, there are a few reports on the use of **1** in organic synthesis.[2] We now found that the reductive debromination of 1,2-bis(bromomethyl)-benzene was efficiently occurred using **1** and that 1,2,3,4-tetrahydronaphthalenes were obtained in moderate to good yields, when the reaction was carried out in the presence of olefins (Scheme 1).[7,8]

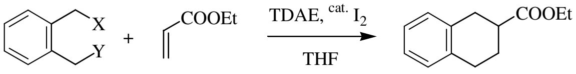


Scheme 1.

The treatment of 1,2-bis(bromomethyl)benzene (**2**) with **1** in the presence of ethyl acrylate (4 equiv) at 67 °C for 6 h produced the 1,2,3,4-tetrahydronaphthalene-2-carboxylic acid ethyl ester (**3**) in 55% yield (entry 3 in Table 1). When the reaction was carried out at 25 °C in the absence of iodine, the reaction did not proceed; however, the reaction was dramatically accelerated by the addition of a catalytic amount of iodine giving **3** in 64% yield (entries 1 and 2).[10] The yield of **3** was improved using a small excess amount of **1** (1.2 equiv) and **3** was obtained in 97% yield (entry 5). In the case of 1-bromomethyl-2-chloromethylbenzene, the yield of the 1,2,3,4-tetrahydronaphthalene-2-carboxylic acid ethyl ester was low due to the formation of various by-products (entry 6). For the reaction of 1,2-bis(chloromethyl)benzene, the starting material (77%) was recovered (entry 7).

The results of the reaction of 1,2-bis(bromomethyl)benzene (**2**) with TDAE in the presence of various olefins are shown in Table 2. Similarly, methyl acrylate, butyl

Table 1. The reaction of 1,2-bis(halogenomethyl)benzene with TDAE in the presence of ethyl acrylate[a]



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Entry	X	Y	TDAE (mmol)	I_2 (mmol)	Temp (°C)	Yield[b] (%)
1	Br	Br	0.5	0	25	0
2	Br	Br	0.5	0.04	25	64
3	Br	Br	0.5	0	67	55
4	Br	Br	0.5	0.04	67	69
5	Br	Br	0.6	0.04	67	97
6	Br	Cl	0.6	0.04	67	21
7	Cl	Cl	0.6	0.04	67	3

[a] Reaction conditions: 1,2-bis(halogenomethyl)benzene (0.5 mmol), ethyl acrylate (2.0 mmol) and THF (5 ml) for 6 h.
[b] GC yield.

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* Corresponding authors. Tel.: +81 6 6368 1121; fax: +81 6 6339 4026; e-mail: nishiya@ipcku.kansai-u.ac.jp

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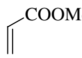
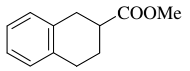
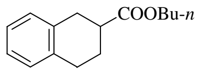
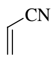
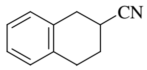
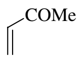
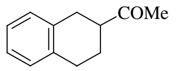
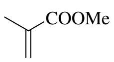
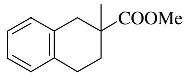
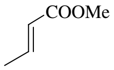
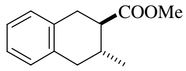
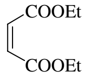
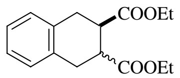
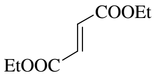
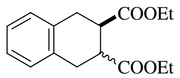
Table 2. The reaction of 1,2-bis(bromomethyl)benzene with TDAE in the presence of various olefins[a]

2

Entry	Olefin	Product	Yield[b] (%)
1			78
2			64
3			69
4			100
5[c]			7
6[c]			32 (*trans*/*cis* = 1/0)
7[c]			51 (*trans*/*cis* = 1/1)
8[c]			44 (*trans*/*cis* = 3/1)

[a] Reaction conditions: 1,2-bis(bromomethyl)benzene (0.5 mmol), TDAE (0.6 mmol), olefin (2.0 mmol), I_2 (0.04 mmol) and THF (5 ml) at 67 °C for 6 h.

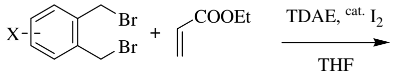
[b] Isolated yield.

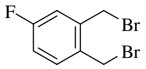
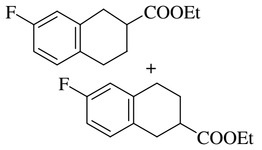
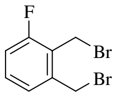
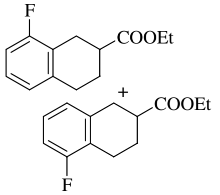
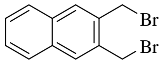
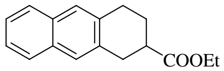
[c] Olefin (5.0 mmol) was used.

acrylate, acrylonitrile and methyl vinyl ketone were coupled to give the corresponding 1,2,3,4-tetrahydronaphthalenes in 64–100% yields (entries 1–4). For the reaction of α-methyl substituted α,β-unsaturated ester such as methyl methacrylate, the yield of cycloaddition product was lower than that of methyl acrylate because of the preparation of various by-products (entry 5). When **2** was allowed to react with **1** in the presence of *trans*-methyl crotonate, *trans*-product was obtained predominantly. On contrary, in the case of diethyl fumarate and diethyl maleate, mixture of *cis*- and *trans*-isomers were formed.

The treatment of 1,2-bis(bromomethyl)-4-fluorobenzene or 1,2-bis(bromomethyl)-3-fluorobenzene with TDAE (**1**) in the presence of ethyl acrylate gave the corresponding 1,2,3,4,-dehydronaphthalene derivatives in 67% and 73% yields, respectively (entries 1 and 2 in Table 3). 1,2,3,4-Tetrahydroanthracene-2-carboxylic acid ethyl ester was also prepared in 84% yield by the reaction of 1,2-bis(bromomethyl)naphthalene with **1** in the presence of ethyl acrylate (entry 3).

Table 3. The reaction of 1,2-bis(bromomethyl)benzene derivatives with TDAE in the presence of ethyl acrylate[a]



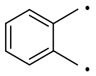
Entry	Substrate	Product	Yield[b] (%)
1[c]			67
2[c]			73
3			84

[a] Reaction conditions: 1,2-bis(bromomethyl)benzene derivative (0.5 mmol), ethyl acrylate (2,0 mmol), TDAE (0.6 mmol), I_2 (0.04 mmol) and THF (5 ml) at 67 °C for 6 h.

[b] Isolated yield.

[c] The ratio of isomers was not determined.

Although detailed study of the reaction pathway has not yet been completed, the present reaction can be understood by assuming the following reaction pathway. Transfer of an electron from TDAE (**1**) to α,α′-dihalogen substituted *o*-xylenes, elimination of Br^-, another electron transfer from **1** or $(TDAE)^+ Br^-$ species, following by elimination of Br^- forms the biradical (**4**) or quinodimethane. The biradical (**4**) or quinodimethane reacted with olefins to give the 1,2,3,4-tetrahydronaphthalenes. At the present time, however, other possibilities cannot be rigorously ruled out.



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In summary, we found that the reductive debromination of 1,2-bis(bromomethyl)benzene was successfully achieved using **1** as a reducing agent. Furthermore, the application of the reaction and elucidation of the reaction pathway are now in progress.

Acknowledgements

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References and notes

1. Kuwata, K.; Geske, D. H. *J. Am. Chem. Soc.* **1964**, *86*, 2101.
2. There are some reports on the use of TDAE in organic synthesis; (i) reductive dehalogenation of α,α-difluoro and

α,α,α-trifluoro substituted alkyl bromide and iodide,[3] (ii) defluorination of fluorinated compounds,[4] (iii) reductive cleavage of chalcogen–chalcogen bond[5] and (iv) reduction of high valent transition metal species[6].

3. Bürger, H.; Moritz, P. *Organometallics* **1993**, *12*, 4930.
4. (a) Peng, W.; Zhu, S. *Tetrahedron* **2003**, *59*, 4395; (b) Takechi, N.; Ait-Mohand, S.; Médebielle, M.; Dolbier, W. R., Jr. *Tetrahedron Lett.* **2002**, *42*, 4317; (c) Médebielle, M.; Kato, K.; Dolbier, W. R., Jr. *Synlett* **2002**, 1541; (d) Takechi, N.; Ait-Mohand, S.; Médebielle, M.; Dolbier, W. R., Jr. *Org. Lett.* **2002**, *4*, 4671; (e) Ait-Mohand, S.; Takechi, N.; Médebielle, M.; Dolbier, W. R., Jr. *Org. Lett.* **2001**, *3*, 4271; (f) Billard, T.; Langlois, B. R.; Médebielle, M. *Tetrahedron Lett.* **2001**, *42*, 3463; (g) Petrov, V. A. *Tetrahedron Lett.* **2001**, *42*, 3267; (h) Burkholder, C.; Dolbier, W. R., Jr.; Médebielle, M.; Ait-Mohand, S. *Tetrahedron Lett.* **2001**, *42*, 3077; (i) Médebielle, M.; Keirouz, R.; Okada, E.; Ashida, T. *Synlett* **2001**, 821; (j) Yagupolskii, L. M.; Fedyuk, D. V. *Tetrahedron Lett.* **2000**, *41*, 2265; (k) Burkholder, C.; Dolbier, W. R., Jr.; Médebielle, M. *J. Org. Chem.* **1998**, *63*, 5385; (l) Burkholder, C.; Dolbier, W. R., Jr.; Médebielle, M. *Tetrahedron Lett.* **1997**, *38*, 821; (m) Chambers, R. D.; Gray, W. K.; Korn, S. R. *Tetrahedron* **1995**, *48*, 13167; (n) Briscoe, M. W.; Chambers, R. D.; Mullins, S. J.; Nakamura, T.; Vaughan, J. F. S.; Drakesmith, F. G. *J. Chem. Soc., Perkin Trans. 1* **1994**, 3115.
5. (a) Pooput, C.; Médebielle, M.; Dolbier, W. R., Jr. *Org. Lett.* **2004**, *6*, 301; (b) Kolomeitsev, A.; Médebielle, M.; Kirsch, P.; Lork, E.; Röschenthaler, G.-V. *J. Chem. Soc., Perkin Trans. 1* **2000**, 2183.
6. (a) Kuroboshi, M.; Waki, Y.; Tanaka, H. *Synlett* **2002**, 637; (b) Kuroboshi, M.; Tanaka, M.; Kishimoto, S.; Goto, K.; Mochizuki, M.; Tanaka, H. *Tetrahedron Lett.* **2000**, *41*, 81; (c) Kuroboshi, M.; Goto, K.; Mochizuki, M.; Tanaka, H. *Synlett* **1999**, 1930.
7. It is known that TDAE is the preferred reagent for matrix electron transfer and EPR spectroscopy and the matrix isolation of 3,4-dimethylenethiophene in the presence of TDAE was observed. See: (a) Greenberg, M. M.; Blackstock, S. C.; Stone, K.; Berton, J. A. *J. Am. Chem. Soc.* **1989**, *111*, 3671; (b) Haider, K.; Platz, M. S. *J. Am. Chem. Soc.* **1988**, *110*, 2318.
8. Many methods for the preparation of 1,2,3,4-tetrahydronaphthalenes by the reaction of α,α'-dihalogen substituted *o*-xylenes with olefins have been developed.[9] However, these methods have some problems in the case of actual use as follows: (i) heterogeneous reaction conditions, (ii) the use of activation of metals, (iii) the limitation of the substrates or (iv) moderate yields of products.
9. (a) Kise, N.; Mimura, R.; Ueda, N. *Bull. Chem. Soc. Jpn.* **2002**, *59*, 2693; (b) Segura, J. L.; Martin, N. *Chem. Rev.* **1999**, *99*, 3199; (c) Inaba, S.; Wehmeyer, R. M.; Forkner, M. W.; Rieke, R. D. *J. Org. Chem.* **1988**, *53*, 339; (d) Kambe, N.; Tsukamato, T.; Miyoshi, N.; Murai, S.; Sonoda, N. *Bull. Chem. Soc. Jpn.* **1986**, *59*, 3013; (e) Stephan, D.; Gorgues, A.; Coq, A. L. *Tetrahedron Lett.* **1984**, *25*, 5649; (f) Ito, Y.; Yonezawa, K.; Saegusa, T. *J. Org. Chem.* **1974**, *39*, 2769; (g) Cava, M. P.; Napier, D. R. *J. Am. Chem. Soc.* **1957**, *79*, 1701, and references therein.
10. When 1,2-bis(iodomethyl)benzene, which was generated by the reaction of 1,2-bis(bromomethyl)benzene with NaI, was allowed to react with TDAE in the presence of ethyl acrylate at 25 °C for 6 h, the same reaction occurred efficiently to give 1,2,3,4-tetrahydronaphthalene-2-carboxylic acid ethyl ester (**3**) in almost quantitatively yield.