

Convenient and Simple Preparation of Nitroolefins Nitration of Olefins with Nitric Oxide

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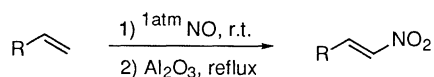
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Nitroolefins are conveniently prepared in high yields by nitration of olefins under an atmospheric pressure of nitric oxide at room temperature and subsequent treatment with acidic alumina.

Nitric oxide, a small and simple gaseous molecule which behaves as a free radical, is of growing importance today in the field of biochemistry,¹ medical science² and environmental science.³

From the standpoint of synthetic organic chemistry, nitric oxide, a commercially available gas,⁴ is a promising nitrogen source. However, little information on the chemical reactivity of nitric oxide has been given and its application to the synthetic organic chemistry is actually quite limited compared with other nitrogen oxides such as nitrogen dioxide^{5,6} which exists in equilibrium with dinitrogen tetroxide. For example, 1,2-diamines⁷ or oximes⁸ were obtained from olefins by using nitric oxide together with transition metal complex and hydride such as lithium aluminum hydride or sodium borohydride. Recently, it was reported that aromatic nucleus of catecholamines were nitrated using nitric oxide in the presence of oxygen. It was already reported from our laboratory that nitric oxide reacted with α,β -unsaturated carboxamides in the coexistence of silyl hydride and a catalytic amount of cobalt(II) complex to give the corresponding α -nitrosocarboxamides in good yields.⁹ Through our study on the reaction of nitric oxide with various organic compounds, nitric oxide itself was found to react smoothly with olefins in 1,2-dichloroethane under mild conditions to afford the corresponding nitroolefins, a versatile synthetic intermediates,¹⁰ in good yields. Although the reaction of nitric oxide with olefins had already appeared in communications¹¹ and patents,¹² the reaction conditions were rather severe to form several undesirable by-products, and yields and selectivities of nitroolefins were not satisfactory. Concerning the synthesis of nitroolefins from olefins, a lot of synthetic methods using nitrite¹³ or nitrogen dioxide⁵ as a source of nitro group were proposed.

In this communication, we would like to describe a convenient and simple method for the preparation of nitroolefins from various olefins with nitric oxide (atmospheric pressure) under mild conditions.



Scheme 1.

In the first place, effect of solvents was examined for nitration of 4-phenyl-1-butene (**1**) under an atmospheric pressure of nitric oxide at room temperature. When haloalkanes, especially 1,2-dichloroethane (EDC) was employed as a solvent, the solution changed from colorless to yellowish green in a few

minutes and the corresponding nitroolefin **2** was obtained in 76% together with 23% yield of nitroalcohol **3** without accompanying any other by-products formed by nitration of aromatic nucleus (Entry 1).¹⁴ Alternatively, benzene could be a suitable solvent as well as haloalkanes (Entry 3).

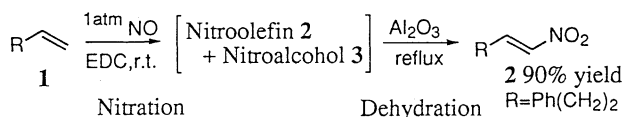
Table 1. Nitration of 4-Phenyl-1-butene with Nitric Oxide in Various Solvents^a

Entry	Solvents	Reaction Time /h	Conversion /% ^b	Yield /% ^b	
				2	3
1	ClCH ₂ CH ₂ Cl	3	100	76	23
2	CCl ₄	1.5	94	53	25
3	PhH	1.5	95	61	23
4	EtOAc	24	14	2	0
5	1,4-Dioxane	24	40	20	4
6	THF	24	0	—	—

^aReaction conditions; 4-phenyl-1-butene 1.0 mmol, Solvent 5.0 cm³, r.t., 1 atm NO. ^bDetermined by GC analysis.

It is noted that EDC is an excellent solvent for the present nitration reaction without forming any organic products other than nitroolefin and nitroalcohol. Concerning transformation of nitroalcohols into nitroolefins by dehydration, the use of several dehydrating reagents was reported.¹⁵ Then, post-treatment of the resulted reaction mixture was investigated using **1** as a model substrate in order to establish a simple procedure for dehydration of nitroalcohol into nitroolefin. Of various dehydrating reagents screened, acidic alumina was found to be the most effective: gently refluxing of the nitration reaction mixture shown in Entry 1 (Table 1) for 30 minutes in the presence of acidic alumina afforded **2** in 90% isolated yield (Scheme 2). Filtration of the reaction mixture through Celite pad and evaporation of the solvent gave satisfactory NMR spectrum without further purification, while employment of neutral and basic alumina¹⁶ resulted in much lower yields than the above acidic one.

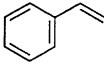
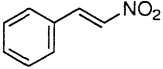
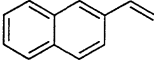
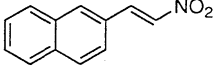
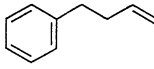
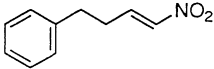
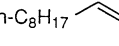
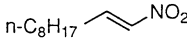
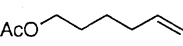
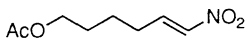
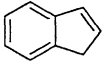
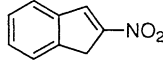
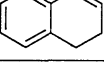
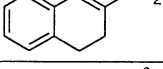
The procedure was successfully applied to the preparation of various nitroolefins as shown in Table 2. Both styrene and 2-vinylnaphthalene afforded (E)-2-phenylnitroethylene and (E)-2-naphthyl nitroethylene in 95% or 90% yield, respectively (Entries 1 and 2). Nitration of terminal olefins not conjugated with aromatic ring also proceeded smoothly to afford the corresponding (E)-nitroolefins in more than 90% yield (Entries 3 to 5). Cyclic olefins conjugated with aromatic ring such as indene or 1,2-dihydronaphthalene also afforded the corresponding nitroolefins having nitro group at β -position (Entries 6 and 7).



Scheme 2.

A typical procedure is described for the nitration of 4-phenyl-1-butene; the flask containing a solution of 4-phenyl-1-butene (1, 132 mg, 1.0 mmol) in EDC 5.0 cm³ was evacuated, then was filled with nitric oxide gas, and the solution was stirred under an atmospheric pressure of nitric oxide at room temperature for 3 h. After nitric oxide was vented, acidic alumina¹⁷ 1.20 g was added into the reaction mixture and stirred under gentle reflux for 30 minutes. Then, the reaction mixture was filtered through Celite pad and the residual alumina was washed with EDC several times. After the removal of the solvent under reduced pressure, 1-nitro-4-phenyl-1-butene (2) 159 mg (90% yield based on 1) was obtained.

Table 2. Nitration of Various Olefins with Nitric Oxide^a

Entry	Substrate	Product ^b	Yield /% ^c
1			95 ^d
2			90 ^e
3			90
4			92
5			91
6			91 ^f
7			86 ^g

^aReaction conditions; substrate 1.0 mmol, EDC 5.0 cm³, r.t., 1 atm NO, then acidic Al₂O₃ 1.20 g, reflux. ^bSatisfactory NMR and IR were obtained after filtration through Celite pad. ^cIsolated yield. ^dMp 56-57 °C (after silica-gel chromatography). ^eMp 120-122 °C (after silica-gel chromatography). ^fMp 139-140 °C. ^gPurified by column chromatography on silica gel.

It is noted that, various olefins are effectively converted into the corresponding nitroolefins in high yields by nitration under an atmospheric pressure of nitric oxide in EDC and successive treatment with acidic alumina. Thus, the present procedure provides a useful method for the preparation of nitroolefins just from olefins. Attempts to expand the scope of olefins and

studies on the detailed mechanism of the present reaction are now under in progress.

References and Note

- 1 T. M. Dawson, V. L. Dawson, and S. H. Snyder, *Ann. Neurol.*, **32**, 297 (1992) and references cited therein.
- 2 H. Selldén, P. Winberg, L. E. Gustafsson, B. Lundell, K. Böök, and C. G. Frostell, *Anesthesiology*, **78**, 577 (1993).
- 3 S. Morikawa, "Kihon Kogyo Shokubai-hanno," ed by Shokubai Gakkai, Kodansya, Tokyo (1985), Chap.14.
- 4 Production and industrial use: K. Jones, "Comprehensive Inorganic Chemistry," Vol. 2, ed by A. F. Trotman-Dickenson, Pergamon Press, Oxford (1973), p. 323.
- 5 W. K. Seifert, *J. Org. Chem.*, **28**, 125 (1963).
- 6 H. Suzuki, T. Murashima, K. Shimizu, and K. Tsukamoto, *Chem. Lett.*, **1991**, 817.
- 7 P. N. Becker, M. A. White, R. G. Bergman, *J. Am. Chem. Soc.*, **102**, 5676 (1980).
- 8 T. Okamoto, K. Kobayashi, S. Oka, and S. Tanimoto, *J. Org. Chem.*, **52**, 5089 (1987).
- 9 K. Kato and T. Mukaiyama, *Chem. Lett.*, **1990**, 1395 and 1917; K. Kato and T. Mukaiyama, *Chem. Lett.*, **1992**, 1137.
- 10 D. Seebach, E. W. Colvin, F. Lehr, and T. Weller, *Chimia*, **33**, 1 (1979); A. G. M. Barrett and G. G. Graboski, *Chem. Rev.*, **86**, 751 (1986); A. G. M. Barrett, *Chem. Soc. Rev.*, **20**, 95 (1991); G. W. Kabalka and R. S. Varma, *Org. Prep. Proced. Int.*, **19**, 283 (1987).
- 11 J. F. Brown, Jr., *J. Am. Chem. Soc.*, **79**, 2480 (1957); J. Tuailon and R. Perrot, *Helv. Chim. Acta*, **61**, 558 (1978).
- 12 Phillips Petroleum Co., U. S. Patent 3658922 (1972); E. I. du Pont de Nemours & Co., U. S. Patent 2656395 (1953); General Electric Co., U. S. Patent 2867669 (1959).
- 13 E. J. Corey and H. Estreicher, *J. Am. Chem. Soc.*, **100**, 6294 (1978); J. R. Hwu, K. -L. Chen, and S. Ananthan, *J. Chem., Soc. Chem. Commun.*, **1994**, 1425; S. -S. Jew, H. -D. Kim, Y. -S. Cho, and C. -H. Cook, *Chem. Lett.*, **1986**, 1747; T. Hayama, S. Tomoda, Y. Takeuchi, and Y. Nomura, *Tetrahedron Lett.*, **1982**, 4733.
- 14 Nitroolefins were yielded under exactly deaerated and dehydrated conditions, and generation of nitrogen was observed in the present reaction. Therefore, it is reasonable to assume that nitric oxide (NO) behaves as a oxygen atom source of nitro group (NO₂) of resulting nitroolefins.
- 15 P. Knochel and D. Seebach, *Synthesis*, **1982**, 1017; D. Seebach and P. Knochel, *Helv. Chim. Acta*, **67**, 261 (1984); M. Miyashita, R. Yamaguchi, and A. Yoshikoshi, *Chem. Lett.*, **1982**, 1505; D. Ranganathan, C. B. Rao, S. Ranganathan, A. K. Mehrotra, R. Iyengar, *J. Org. Chem.*, **45**, 1185 (1980).
- 16 R. Ballini, R. Castagnani, and M. Petrini, *J. Org. Chem.*, **57**, 2160 (1992).
- 17 Merck Art.1078, aluminium oxide 90, activity I according to Brockmann, 70 - 230 mesh, acidic for column chromatography.