

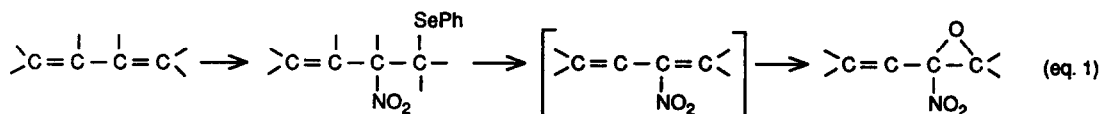
NITROSELENATION OF CONJUGATED DIENES. PREPARATION OF 3,4-EPOXY-3-NITRO-1-ALKENES

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Summary. Conjugated dienes were transformed to synthetically useful 3,4-epoxy-3-nitro-1-alkenes via a nitroselenation-oxidation sequence.

Electron-deficient conjugated dienes are useful building blocks that recently have attracted some interest.²⁻⁷ The synthetic utility of these dienes increases if the electron-withdrawing group can be eliminated or substituted at a later stage. An example of such an electron-withdrawing group is arylsulfonyl, and several methods for the preparation of 2-arylsulfonyl-1,3-dienes have recently been reported.²⁻⁵ Another electron-withdrawing group of great interest that can be substituted or undergo further interesting transformations is the nitro group.⁸


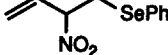

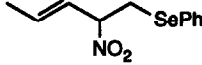

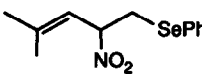

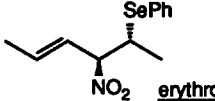
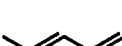
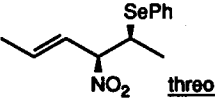

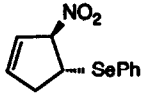

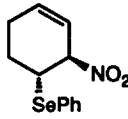

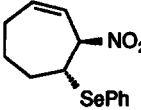
In one of the procedures for preparation of 2-phenylsulfonyl-1,3-dienes a sulfonylselenation (selenosulfonation) of the diene was used. With the aim of preparing 2-nitro-1,3-dienes we decided to investigate the corresponding nitroselenation⁹ of conjugated dienes. We now report on a stereo- and regiospecific nitroselenation of conjugated dienes and subsequent transformation of the adducts to 3,4-epoxy-3-nitro-1-alkenes (eq. 1).



Nitroselenation of monoolefins is known in the literature⁹ but nothing has been reported on the corresponding reaction with conjugated dienes. Encouraged by the success of sulfonylselenation of conjugated dienes,^{5a} we studied the nitroselenation of these substrates. Reaction of the conjugated diene with PhSeBr/AgNO₂ in the presence of HgCl₂⁹ resulted in a highly regio- and stereospecific nitroselenation of one of the double bonds. Results from addition to a few representative dienes are shown in Table I. In all cases tried the 1,2-monoadduct with selenium in the 1-position was formed. Reaction of (*E,E*)- and (*E,Z*)-2,4-hexadiene afforded *erythro*- and *threo*-adducts respectively, showing the *trans* stereospecificity of the reaction (entries 4 and 5). Cyclic dienes afforded *trans*-adducts (entries 6 - 8).

Attempts to prepare 2-nitro-1,3-dienes by oxidative elimination of selenium from the nitroselenation adducts failed. This reaction works well for nitroselenation adducts of monoolefins to give vinyl nitro compounds.⁹ Furthermore, the corresponding sulfonylselenation adducts from 1,3-dienes afforded

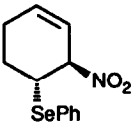
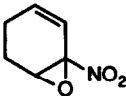
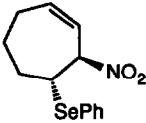
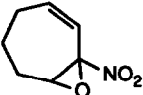
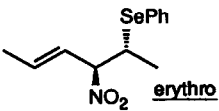
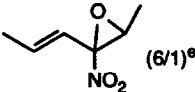
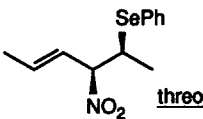
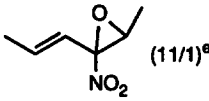
Table I. Nitroselenation of 1,3-dienes.^a

entry	Diene	Reaction time	Product	Yield ^b (%)
1		5h		(74) ^c
2		4h		(76) ^c
3		4h		51 (75)
4		2.5h	 erythro	40 (75)
5		4.5h	 threo	58 (71)
6		3h		43 (68)
7		2h		50 (68)
8		3h		51 (62)

a. In a typical procedure 1,3-cyclohexadiene (80 mg, 1 mmol) was added to a solution of PhSeBr (0.236 g, 1 mmol) in dry THF (5 ml) at -78 °C under nitrogen. After 10 min of stirring, HgCl₂ (0.41 g, 1.5 mmol) was added and a solution of AgNO₂ (0.17 g, 1.1 mmol) in acetonitrile (5 ml) was added over 30 min. The resulting mixture was stirred for 2h and then allowed to warm to room temperature and stirred for another 2h. The precipitates were filtered off through celite and washed with ether (15 ml). The organic phase was washed with brine (3 x 7 ml), water (3 x 7 ml), 0.5 M NaOH (2 x 7 ml) and dried (MgSO₄). Evaporation of the solvent in vacuo afforded 0.266 g of the product contaminated with the oxyseleation adduct 3-hydroxy-4-(phenylselenyl)cyclohexene (N-attack : O-attack = 72 : 28). After flash chromatography (silica, petroleum ether/ether = 10/1) 0.141 g (50%) of pure *trans*-3-nitro-4-(phenylselenyl)cyclohexene was obtained. b. Isolated yields after chromatography. Yields in parenthesis are NMR yields determined on the crude products. Partial decomposition of the product occurred on the silica gel column. c. The product could not be purified by flash chromatography because of decomposition on the silica column.

2-phenylsulfonyl-1,3-dienes on oxidation.^{5a} The expected 2-nitro-1,3-dienes from oxidation of nitroselenation adducts apparently undergo further transformations under the reaction conditions employed. However, we found that it was possible to trap the anticipated nitrodiene as its monoepoxide. Thus, reaction of the nitroselenation

Table II. Nitroepoxides from nitroseleno compounds^a

Starting material	Product	Yield ^b (%)
		68 ^c
		41 ^d
		40 ^c
		45 ^{c,f}

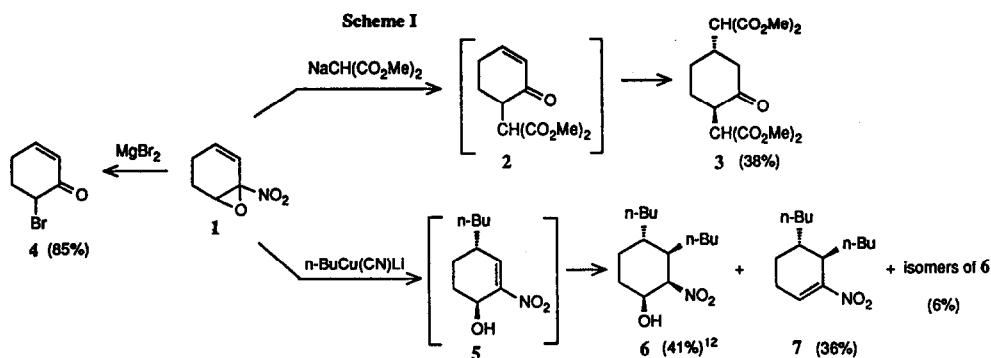
a. Reaction conditions: MeOH/H₂O₂, NaOH, 5 min. b. Isolated yield after flash chromatography. c. Based on the purified starting material (cf. Table I). d. Based on the crude starting material. e. E / Z - ratio for the epoxide ring (¹H NMR, 300 MHz). f. Crude ¹H NMR yield (300 MHz)

adducts with an excess of H₂O₂ in the presence of NaOH afforded a 3,4-epoxy-3-nitro-alkene. A few examples are given in Table II. Epoxidation of electron-deficient olefins is known to occur readily with alkaline H₂O₂,¹⁰ which indicates that the 2-nitro-1,3-diene is formed in situ.

The monoepoxides obtained from the nitroselenation adducts (Table II) should be useful synthons analogous to the corresponding 1,2-epoxy-2-(phenylsulfonyl)-3-alkenes.^{6a} Two examples of further transformation of these nitroepoxides are given in Scheme I. Reaction of **1** with sodium dimethyl malonate produced **3** as the major product. Presumably an intermediate α,β -unsaturated ketone **2** is formed, which is considerably more reactive towards the dimethyl malonate anion than **1**. In the reaction of **1** with MgBr₂ the α,β -unsaturated ketone **4**, related to **2**, was isolated. Reaction of **1** with butylcyanocuprate is expected to give **5**,¹¹ but again the adduct reacts further via a Michael addition to give **6**¹² and **7** as the major products.¹³ Thus a double nucleophilic addition to **1** can be achieved and, depending on the nucleophile, a 1,4- or a 1,2-addition to the 3,4-epoxy-3-nitro-1-alkene can take place.

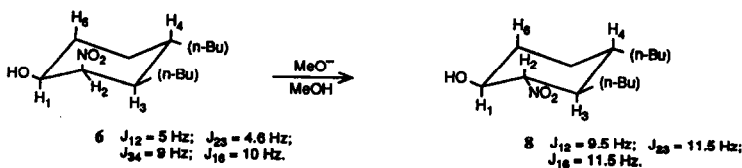
It is not yet clear why the 2-nitro-1,3-dienes are so reactive and difficult to isolate since the corresponding 1-nitro-1,3-dienes have been prepared and are quite stable.^{7a} Further work is needed before it will be possible to isolate these potentially interesting 2-nitro-1,3-dienes.

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References and Notes

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- The structure of **6** was assigned from its ¹H NMR spectral data (COSY, NOE, decoupling). It was shown that **6** isomerized to **8** on treatment with base. Compound **8** was present in the fraction "isomers of **6**".



- The yields given in Scheme I are the isolated yields after purification by flash chromatography.

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