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Addition of Nitrite Ions to 1-Methoxy-1,2,3-triazolium Salts. Formation of Nitro and Hydroxy Substituted Triazoles

MIKAEL BEGTRUP and NIELS OLE KNUDSEN

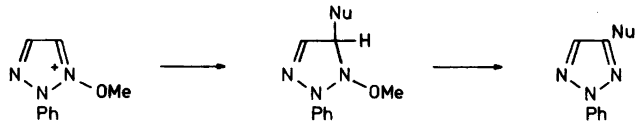
Department of Organic Chemistry, The Technical University of Denmark, DK-2800 Lyngby, Denmark

Potassium and silver nitrite add to 1-methoxy-2-phenyltriazolium salts as ambident nucleophiles to give 4-nitro- and 4-hydroxytriazoles. If unsubstituted, the latter, *via* nitrosation and oxidation, affords 4-hydroxy-5-nitro-2-phenyltriazole. The hydroxytriazoles add to unchanged starting material producing bistriazolyl ethers. A nitro-substituted derivative of the latter displays photochromic properties.

1-Methoxy-2-phenyl-1,2,3-triazolium tetrafluoroborates react with a variety of nucleophiles with addition followed by elimination of methanol to produce 4-substituted 2-phenyltriazoles (Scheme 1).[1] This paper deals with the reaction of the salts (*1*; X = H or Me) with the ambident nitrite ion to give several products.

Thus, the 1-methoxytriazolium salt (*1*; X = Me), when treated for 3 d at 20 °C with potassium or silver nitrite in acetonitrile, yields the nitrotriazole (*2*; X = Me) and the hydroxytriazole (*4*; X = Me) in substantial amounts (yields in Table 1). These are the result of an attack of nitrite nitrogen and oxygen, respectively, the hydroxytriazole arising by loss of nitrogen oxide from initially formed nitrit (*3*; X = Me). The bistriazolyl ether (*5*; X = Y = Me) is isolated as a byproduct most likely arising by addition of initially formed hydroxytriazole (*4*; X = Me) to unchanged starting material (*1*; X = Me), followed by elimination of methanol, a known reaction.[1] Finally, the triazole-1-oxide (*9*; X = Me) is formed by *O*-dealkylation of the starting material (*1*; X = Me).[1] Silver nitrite is superior to potassium nitrite producing higher yields of both nitro- and hydroxytriazole. In addition, the silver salt produces a higher *N*-addition – *O*-addition ratio (0.78) than potassium nitrite (0.51) as is the case when the two nitrites are used in aliphatic nucleophilic substitution reactions.[2]

The 1-methoxytriazolium salt (*1*; X = H) when treated with potassium nitrite yields the corresponding products, yet supplemented with the nitrohydroxytriazole (*7*) and the nitro-substituted bistriazolyl ether (*5*; X = H, Y = NO_2), both formed in substantial quantities (Table 1). The former compound may arise when one molecule of the intermediate nitrite (*3*; X = H) nitrosates a second. This affords hydroxynitrosotriazole (*6*), which in turn is oxidized to *7*. Most likely, the oxidation takes place during the acidic work-up which is essential for the isolation of *7*. Nitrous acid, evolved by the acidification, is known to be able to oxidize nitroso to nitro groups.[3–6] That nitrosation, in contrast to oxidation, takes place prior to work-up appears from the fact that the hydroxytriazole (*4*; X = H), though susceptible to electrophilic substitution as shown by its ready nitration by nitric acid (see Experimental), remains unchanged upon treatment with aqueous nitrous acid under the conditions of work-up. The hydroxytriazole (*4*; X =



Scheme 1.

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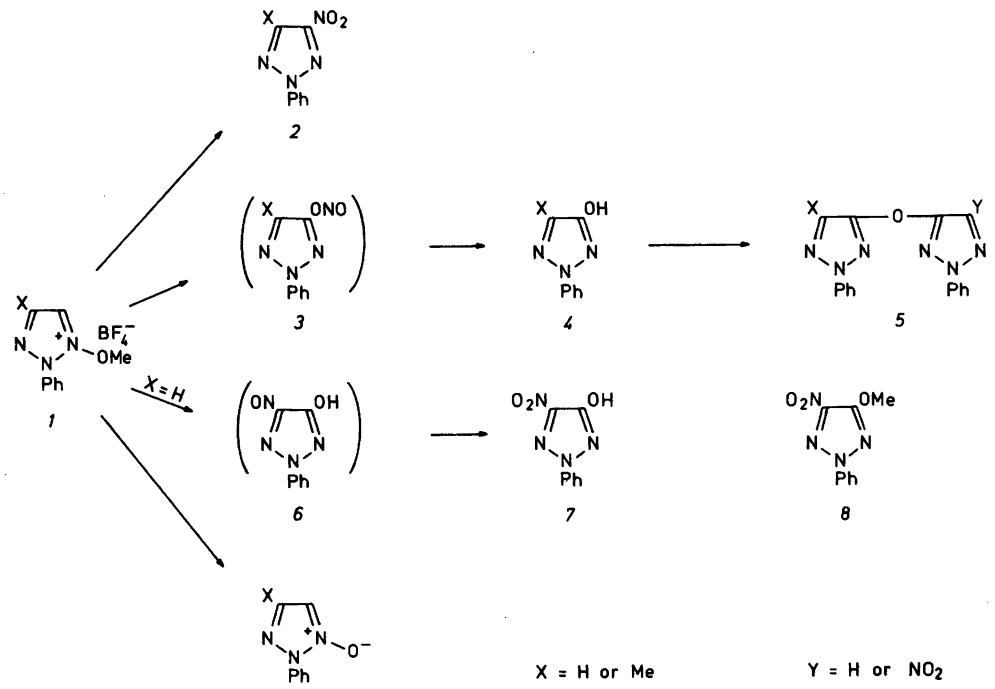
Table 1. Yields of products obtained by reaction of 1-methoxy-2-phenyl-1,2,3-triazolium tetrafluoroborates (*1*; X=H or Me) with potassium or silver nitrite.

Starting material	Product	Yield; KNO_2 as nucleophile %	Yield; $AgNO_2$ as nucleophile %
1; X=Me	*2*; X=Me	14	27
	4; X=Me	24	32
	5; X=Y=Me	7	5
	9; X=Me	48	14
1; X=H	*2*; X=H	18	23
	4; X=H	1	9
	5; X=Y=H	8	8
	7	32	46
	5; X=H, Y=NO_2	19	0
	9; X=H	11	10

H) could not be nitrosated with iso-amyl nitrite in ethanol, neither under neutral conditions nor in the presence of sodium ethoxide. Nitrosation prior to work-up is also indicated by the absence of the nitro substituted bistriazolyl ether (*5*; X=H, Y=NO_2) when the starting material (*1*; X=H) is treated with hydroxynitrotriazole *7* under the conditions of work-up while *5*; (X=H, Y=NO_2) is obtained in 69 % yield when *1* and *7* are reacted under non-aqueous basic conditions.

When the 1-methoxytriazolium salt (*1*; X=H) is treated with silver nitrite, no significant change in the *N*-addition–*O*-addition product ratio is observed (KNO_2 0.32; $AgNO_2$ 0.33) but total yields of nitro-, hydroxy-, and nitrohydroxytriazole (*2*; X=H, *4*; X=H, and *7*) increase. In contrast, no



Scheme 2.

nitro-substituted bistriazolyl ether (*5*; X=H, Y=NO_2) is formed (Table 1).

When applicated on a TLC plate the nitro-substituted bistriazolyl ether (5; X=H, Y=NO_2) turns intensively emerald green on irradiation with UV-light of wavelength below 540 nm.

EXPERIMENTAL

Solvents were removed *in vacuo*. Flash chromatography was performed as described.[1] The purity and identity of all compounds were confirmed through TLC, m.p., IR, ^{1}H NMR and MS. ^{1}H NMR spectra were recorded on a Bruker HX-90 instrument. Mass spectra were obtained on a V. G. Micromass 7090 F instrument.

1-Methoxy-4-methyl-2-phenyl-1,2,3-triazolium tetrafluoroborate (*1*: X=Me)[1] (0.37 g), potassium nitrite (0.34 g), and dry acetonitrile (3.6 ml) were stirred for 3 d. The acetonitrile was removed and the residue extracted with acetone (4 × 10 ml). The residue was acidified (hydrochloric acid), the water removed, and the residue extracted with acetone (4 × 10 ml). Both acetone solutions were combined and the solvent removed. Preparative TLC (dichloromethane–hexane [1:1]) gave 38 mg (14 %) of *4-methyl-5-nitro-2-phenyl-1,2,3-triazole* (*2*; X=H), m.p. 113–114 °C. Recrystallization (ethyl acetate–hexane) gave a product with m.p. 114 °C. Anal. $C_9H_8N_4O_2$: C, H, N. ^{1}H NMR ($CDCl_3$) δ 8.15–8.0 and 7.65–7.35 (2H, m, and 3H, m, Ph), 2.68 (3H, s, Me). MS (70eV) 204 (100 %, M^+). The subsequent fraction contained 16 mg (7 %) of bis(4-methyl-2-phenyltriazol-5-yl) ether (*5*; X=Y=Me), identical with the material described below. Further elution with ethyl acetate–hexane (1:4) gave 55 mg (24 %) of 4-hydroxy-5-methyl-2-phenyltriazole (*4*; X=Me), identical with the material below, and 0.11 g (48 %) of 4-methyl-2-phenyltriazole-1-oxide (*9*; X=Me), identical with the material described previously.[1]

A mixture of *1*; (X=Me) (0.33 g), silver nitrite[7] (0.57 g), and acetonitrile (3.3 ml), after stirring for 3 d and removal of the acetonitrile, gave a residue which was extracted with acetone (5 × 10 ml). Removal of the acetone and preparative TLC (dichloromethane–hexane [1:1]) gave 4-methyl-5-nitro-2-phenyltriazole (*2*; X=Me), and an oil. The plate was then eluted with ethyl acetate which caused the band at the base line to move. It contained 4-methyl-2-phenyltriazole-1-oxide (*9*; X=Me). The above-mentioned oil upon preparative TLC (toluene) produced pure bis(4-methyl-2-phenyltriazol-5-yl) ether (*5*; X=Y=Me). The residue from the extraction of the product mixture with acetone was acidified (4 M hydrochloric acid, 4 ml). Filtration, extraction of the precipitate with acetone (4 × 5 ml), and removal of the acetone furnished 4-hydroxy-5-methyl-2-phenyltriazole (*4*; X=Me). Yields of all products are given in Table 1.

1-Methoxy-2-phenyl-1,2,3-triazolium tetrafluoroborate (*1*; X=H)[1] (0.16 g), potassium nitrite (0.15 g), and acetonitrile (1.6 ml) were stirred for 3 d. The acetonitrile was removed and the residue extracted with acetone (4 × 10 ml). The residue was acidified (hydrochloric acid), the water removed, and the residue extracted with acetone (4 × 10 ml). Both acetone solutions were combined and the solvent removed. Acidification (hydrochloric acid), evaporation to dryness, and flash chromatography (ethyl acetate–hexane [1:1]) gave a fraction which contained *2*; (X=H), *5*; (X=Y=H), *5*; (X=H, Y=NO_2), and *8* (see below). The second fraction contained 1 mg (1 %) of 4-hydroxy-2-phenyltriazole (*4*; X=H), identical with the material described previously.[1] Subsequent elution with ethyl acetate gave 11 mg (11 %) of 2-phenyltriazole-1-oxide (*9*; X=H), identical with the material described previously.[1] Finally, elution with ethyl acetate–methanol (1:1) gave 7 to which 4 M hydrochloric acid (2 ml) was added. The water was removed, the residue extracted with dichloromethane, and the solvent removed to give 40 mg (32 %) of 4-hydroxy-5-nitro-2-phenyltriazole (*7*), m.p. 117–119 °C. Recrystallization (toluene–hexane) raised the m.p. to 126–127 °C. The compound was identical with the material described below. Preparative TLC of the mixture of *2*; (X=H), *5*; (X=Y=H), 5; (X=H, Y=NO_2), and *8* (dichloromethane–hexane |1:1.5|) gave 21 mg (18 %) of *4-nitro-2-phenyl-1,2,3-triazole* (2; X=H), m.p. 124–126 °C. Recrystallization (ethyl acetate–hexane) gave an analytical specimen, m.p. 129–130 °C. Anal. $C_8H_6N_4O_2$: C, H, N. ^{1}H NMR δ ($CDCl_3$) 8.34 (1H, s, H-5), 8.2–8.0 and 7.65–7.45 (2H, m, and 3H, m, Ph). MS (70 eV) 190 (100 %, M^+). The subsequent fraction contained *5* (X=Y=H) and *8* (see below). The third fraction contained 21 mg (19 %) of 4-nitro-2-phenyl-5-(2-phenyltriazol-4-oxy)triazole (*5*; X=H, Y=NO_2), m.p. 168–170 °C, identical with the compound described below. The mixture of *7*; (Y=H) and (*8*) upon preparative TLC (ethyl acetate–hexane |1:4|) gave 7 mg (8 %) of the bis(2-phenyltriazol-4-yl) ether (*5*; X=Y=H), m.p. 76 °C, identical with the material described previously[1] and 2 mg (1 %) 4-methoxy-5-nitro-2-phenyltriazole (*8*), m.p. 125–127 °C, identical with the material described below.

In the same manner, (1; X=H) (0.15 g), silver nitrite[7] (0.28 g), and acetonitrile (1.5 ml) gave the products listed in Table 1.

4-Hydroxy-5-methyl-2-phenyl-1,2,3-triazole (4; X=Me) was prepared analogous to 4-hydroxy-2-phenyltriazole (4; X=H) by (i) treatment of the 1-

methoxytriazolium tetrafluoroborate (*1*; X=Me) with aqueous sodium hydroxide.[1] Yield 53 %. (In addition, 34 % of bis(4-methyl-2-phenyltriazol-5-yl) ether (*5*; X=Y=Me), see below, was isolated); (ii) hydrolysis of 4-acetoxy-5-methyl-2-phenyltriazole.[1] Yield 95 %, m.p. 158–159 °C. (Lit.,[8] 140–142 °C). Anal. $C_9H_9N_3O$: C, H, N. ^{1}H NMR δ ($CDCl_3$) 10.82 broad (1H, s, exchangeable, OH), 7.85–7.65 and 7.55–7.1 (2H, m, and 3H, m, Ph), 2.33 (3H, s, Me). MS (70eV) 175 (100 %, M^+).

4-Hydroxy-2-phenyltriazole (4; X=H)[1] (0.25 g) and conc. nitric acid (3 ml) were stirred for 1 h at 0 °C. Dilution with water (30 ml), extraction with dichloromethane (3 × 10 ml), and removal of the dichloromethane furnished 0.32 g (100 %) of *4-hydroxy-5-nitro-2-phenyl-1,2,3-triazole* (*7*) as yellow crystals, m.p. 127–129 °C. Recrystallization (ether –hexane) did not raise the m.p. Anal. $C_8H_6N_4O_3$: C, H, N. ^{1}H NMR δ ($CDCl_3$) 8.1–7.95 and 7.6–7.4 (2H, m, and 3H, m, Ph), 5.16 broad (1H, s, exchangeable, OH). MS (70 eV) 206 (100 %, M^+).

Bis(4-methyl-2-phenyl-1,2,3-triazol-5-yl) ether (*5*; X=Y=Me) was prepared like bis(2-phenyltriazol-4-yl) ether (*5*; X=Y=H)[1] by treatment of the 1-methoxytriazolium salt (*1*; X=Me) with aqueous sodium hydrogen carbonate. Yield 62 %, m.p. 101 °C (from hexane). Anal. $C_{18}H_{16}N_6O$: C, H, N. ^{1}H NMR δ ($CDCl_3$) 8.0–7.8 and 7.55–7.15 (4H, m and 6H, m, 2 Ph), 2.36 (6H, s, 2 Me). MS (70 eV) 332 (54 %, M^+).

4-Hydroxy-5-nitro-2-phenyltriazole (*7*) (59 mg) and potassium hydroxide (16 mg) were stirred in methanol (1 ml) for 1 h. The methanol was removed and the residue was dried at 1.3 Pa over P_2O_5. Then 1-methoxy-2-phenyltriazolium tetrafluoroborate (*1*; X=H) (75 mg) and dry acetonitrile (0.75 ml) was added. After stirring for 1 day under dry nitrogen the solvent was removed. The residue was extracted with dichloromethane (5 × 2 ml), the solution was filtered through silica gel 0.05–2 mm (2 g), and the dichloromethane was removed to give a residue which was triturated with boiling ether (2 × 2 ml), decanting after cooling to –25 °C. The residue consisted of 70 mg (69 %) of *4-nitro-2-phenyl-5-(2-phenyl-1,2,3-triazol-4-oxy)triazole* (*5*; X=H, Y=NO_2), buff crystals, m.p. 168–171 °C. Recrystallization (ethyl acetate) did not raise the m.p. Anal. $C_{16}H_{11}N_7O_3$: C, H, N. ^{1}H NMR δ ($CDCl_3$) 8.15–7.9 and 7.6–7.3 (4H, m, and 6H, m, 2 Ph), 7.86 (1H, s, H-5). MS (70 eV) 349.091 (100 %, M^+) (Calc.: 349.092). UV (EtOAc) λ_{max} (ε): 273.7 (27000), 311.8 (11000), 355.9 (4000).

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