The Chemistry of α-Nitro-sulfones; II[1]. The Reaction with Sodium Nitrite

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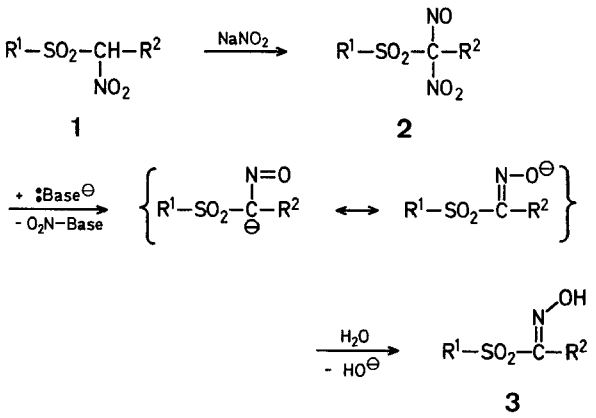
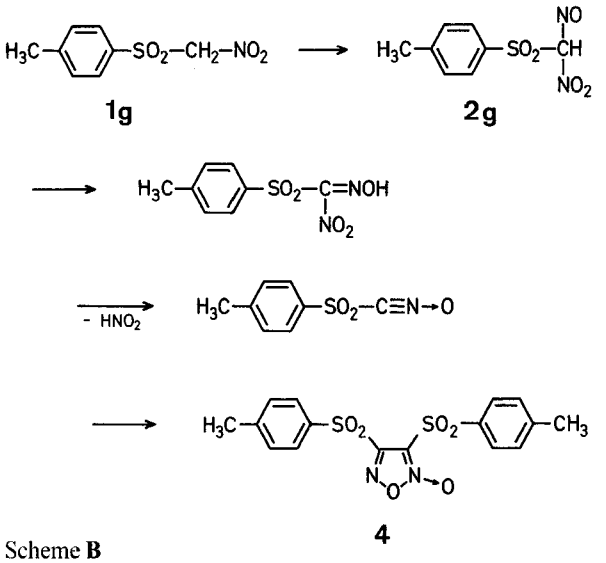
Recently, Kornblum and Wade described[2] a method for the conversion of secondary nitro compounds into ketones by the simultaneous reaction with sodium nitrite and nitrous acid esters. Primary nitro compounds were converted into carboxylic acids and α-nitro-esters into α-oximino-esters[3]; the latter reaction proceeds with sodium nitrite alone[4]. Tertiary nitro compounds do not react.

We found that the reaction of α-nitro-*sec*-alkyl sulfones (**1**) with excess sodium nitrite in 85% aqueous dimethylformamide at room temperature yields α-oximino-*sec*-alkyl sulfones (**3**) in reasonable yields (Table 1). The reaction presumably proceeds according to the same mechanism that has been proposed for the reaction of α-nitro-esters with sodium nitrite[4].



Scheme **A**

The reaction of the primary nitroalkyl sulfone **1g** with sodium nitrite affords minor amounts of the furoxane **4** as the only isolable organic compound; this fact points to the intermediacy of a pseudonitrole[5] (**2g**).



Scheme **B**

The data given in Table 2 demonstrate that α-nitro-sulfones exhibit higher acidities than α-nitro-carboxylic esters; thus, the nitrite ion is sufficiently basic[4] to generate the nitrosulfonylcarbanion postulated as an intermediate in the conversion according to Scheme **A**. Attempts to isolate the pseudonitrole **2a** upon nitrosation of the potassium salt of 4-methylphenyl 1-nitroethyl sulfone (**1a**) with dinitrogen tetroxide in ether[6] at 0° were unsuccessful, apparently because of the instability of **2a**. However the appearance of a blue color (λ_{max} = 653 nm) indicated that **2a** might be formed in the reaction.

Table 1. Reaction of α-Nitro-Sulfones with Sodium Nitrite

Sulfone	R^1	R^2	Reaction time days (d), hours (hr)	Product	Yield (%)	Recovered sulfone (%)	m.p.	I.R. (KBr) ν_{OH} (cm^{-1}) (shoulder)
1a	H_3C-C$_6$H$_4$-	CH_3	16 hr	**3a**[a]	31	–	97.1–97.6°[c] and 146°	3290 (3450)
1a			12 d	**3a**[a]	12.5	–		
1b	H_3C-C$_6$H$_4$-	C_2H_5	16 hr	**3b**[a]	33	–	107.0–108.9°[d]	3305
1b			12 d	**3b**[a]	5	–		
1c	H_3C-C$_6$H$_4$-	C$_6$H$_5$-	16 hr	**3c**[a]	36	47	147.4°[c] (dec)	3290
1c			12 d	**3c**[b]	65	–		
1d	H_3C-C$_6$H$_4$-	CH_3O-C$_6$H$_4$-	9 d	**3d**[b]	68	–	154.1°[c] (dec)	3460 (3390)
1e	H_3C-C$_6$H$_4$-	Cl-C$_6$H$_4$-	9 d	**3e**[b]	54	6.5	146.1°[c] (dec)	3390
1f	C$_6$H$_5$-CH_2-	C$_6$H$_5$-	12 d	**3f**[b].	37	17	126.4°[c] (dec)	3290
1g	H_3C-C$_6$H$_4$-	H	16 hr	**4**[a]	0.5	–	183.3–183.4°[f]	

[a] Purification by chromatography.
[b] Purification by crystallization.
[c] From benzene/hexane (Ref.[20], m.p. 119–120°).
[d] From ether/hexane.
[e] From chloroform/hexane.
[f] From acetone/ethanol (Ref.[5], m.p. 183–184°).

Table 2. Acidities of Some Substituted Nitroalkanes

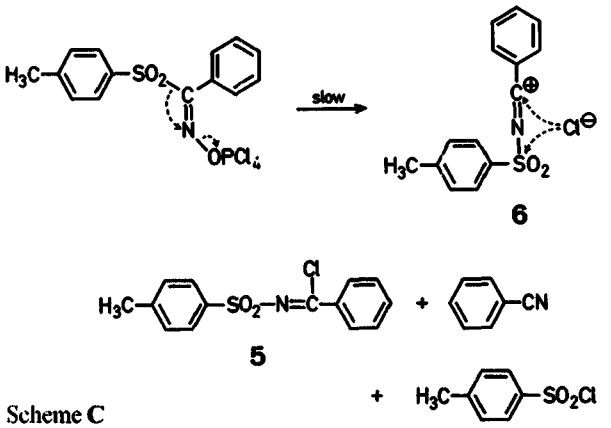
Compound	Solvent: 50% aqueous ethanol[a]	Solvent: water	References
$H_3C-C_6H_4-SO_2-CH(NO_2)-CH_3$ (**1a**)[b]	6.8 at 20°		
$H_3C-C_6H_4-SO_2-CH(NO_2)-C_2H_5$ (**1b**)[b]	6.9 at 20°		
$H_3C-C_6H_4-SO_2-CH_2-NO_2$ (**1g**)[b]	5.7 at 20°		
$O_2N-CH_2-COOC_2H_5$		5.18 at 25°	7
$H_3C-CH(NO_2)-COOC_2H_5$	7.5 at 25°		8
$H_3C-CH_2-CH(NO_2)-COOC_2H_5$	7.6 at 25°		8
$H_3C-C(=O)-CH_2-NO_2$		5.1 at 25°	9
$NC-CH_2-NO_2$		4.86 at 27°	10
$O_2N-CH_2-NO_2$		3.57 at 25°	10

[a] The apparent pK_a values are ~1.5 units higher than the pK_a values determined in water[8].

[b] The acidities were measured using the method of Kornblum[8].

The α-oximino-sulfones **3** are stable, colorless, crystalline compounds. The melting points and spectral data of some solid materials are indicative of the presence of a mixture of the *syn*- and *anti*-forms. For instance, the solid oxime **3a**, which gives a correct elemental analysis, has a shoulder at 3450 cm^{-1} (Table 1) in the I.R.-spectrum and no sharp melting point. Upon dissolving **3a** in chloroform, only one isomer can be detected, presumably[11] the *anti*-form. The ^{1}H-N.M.R. spectrum of **3a** shows only one absorption at $\delta = 2.17$ ppm in $CDCl_3$ for the methyl group in the position α to the oxime function.

The pungent smell of benzonitrile is unmistakable at the decomposition point of oximes **3c–3f**. Indeed, during pyrolysis of **3c** at 170°/15 torr, benzonitrile distilled over (67%, determined by G.L.C.). A Beckmann fragmentation, catalyzed by *p*-toluenesulfonic acid formed upon decomposition, may account for this result. Also upon treatment of **3c** with phosphorus pentachloride in ether at 0° for 45 minutes, benzonitrile (35%) as well as tosyl chloride (20%) and ethyl tosylate (13%) could be detected by means of I.R., ^{1}H-N.M.R., an G.L.C., and *N*-tosylbenzimidoyl chloride (**5**) was isolated in 56% yield. This reaction is reminescent of the behaviour of benzil monoxime, which is converted into *N*-benzoylbenzimidoyl chloride upon reaction with phosphorus pentachloride[12]. Beckmann fragmentations[13] are often considered to occur as side reactions of Beckmann rearrangement[14]. Since there are indications[15] that at least in some cases the Beckmann fragmentation involves a rearrangement as the initial step, we suggest for the reaction of **3c** with phosphorus(V) chloride the mechanism depicted in Scheme C.



Scheme C

We prefer[16] formulation of the second step in Scheme C as a S_N2 reaction of chloride anion with **6** (as in the von Braun reaction[17,18]) to give tosyl chloride; this formulation avoids invoking the unstable tosyl cation[19] as the leaving group.

Melting points were determined using a Mettler FP 1 melting point apparatus with a Mettler FP52 microscope attachment. Elemental analyses were carried out in the Analytical Department of this laboratory under supervision by Mr. W. M. Hazenberg. N.M.R. spectra were recorded on a Varian A-60 spectrometer, using TMS ($\delta = 0$) as an internal standard. I.R. spectra were measured with a Perkin-Elmer instrument, model 257.

The nitro compounds were synthesized[1,20] by reaction of sodium *p*-toluenesulfinate (1.5 equiv) with the appropriate *gem*-bromonitro compound (1.0 equiv) for **1a**, **1b**, and **1g**, or using the method of Truce et al.[21], procedure A, for **1c–1f**.

1d: Crystallized from ethanol; yield: 85%, m.p. 125.5–127.2°.

$C_{15}H_{15}NO_5S$ (321.4) calc. C 56.07 H 4.71 N 4.36 S 9.98; found 55.81 4.78 4.34 9.91

^{1}H-N.M.R. ($CDCl_3$): 6.8–7.8 (m, $8H_{arom}$), 6.42 (s, 1H, SO_2-CH), 3.83 (s, 3H, H_3CO), 2.47 (s, 3H, *p*-CH_3).

1e: Crystallized from ethanol; yield: 22%, m.p. 130.0–130.4°.

$C_{14}H_{12}ClNO_4S$ (325.8) calc. C 51.62 H 3.71 Cl 10.89 N 4.30 S 9.85; found 51.45 3.74 10.95 4.30 9.90

^{1}H-N.M.R. ($CDCl_3$): 7.2–7.8 (m, $8H_{arom}$), 6.45 (s, 1H, SO_2-CH), 2.48 (s, 3H, *p*-CH_3).

Preparation of α-Oximino-sulfones; General Procedure:

To a solution of the α-nitro-sulfone (10 mmol) in dimethylformamide (60 ml) and water (10 ml) at room temperature was added sodium nitrite (2.07 g, 30 mmol). After stirring until the salt had dissolved, the solution was allowed to stand for the appropriate

Table 3. N.M.R. Spectral Data and Elemental Analyses of the New Oximes **3b–3f**

Compound	^{1}H-N.M.R. ($CDCl_3$) δ (ppm)	Elemental Analyses					
3b	7.2–8.0 (m, $4H_{arom}$), 2.64 (q, 2H, CH_2-CH_3), 2.47 (s, 3H, *p*-CH_3), 1.12 (t, 3H, CH_3)	$C_{10}H_{13}NO_3S$ (227.3)	calc.	C 52.85	H 5.76	N 6.16	S 4.11
			found	53.03	5.76	6.05	4.16
3c	7.1–7.8 (m, $9H_{arom}$), 2.42 (s, 3H, *p*-CH_3)	$C_{14}H_{15}NO_3S$ (275.3)	calc.	C 61.08	H 4.76	N 5.08	S 11.65
			found	61.03	4.80	5.14	11.54
3d	6.8–7.9 (m, $8H_{arom}$), 3.83 (s, 3H, CH_3O), 2.45 (s, 3H, *p*-CH_3)	$C_{15}H_{15}NO_4S$ (305.4)	calc.	C 59.00	H 4.95	N 4.59	S 10.50
			found	59.13	4.98	4.52	10.56
3e	7.2–7.9 (m, $8H_{arom}$), 2.45 (s, 3H, *p*-CH_3)	$C_{14}H_{12}ClNO_3S$ (309.8)	calc.	C 54.28	H 3.90	N 4.52	S 10.34	Cl 11.45
			found	54.09	3.95	4.51	10.44	11.61
3f	7.35 (s, $5H_{arom}$), 7.48 (s, $5H_{arom}$), 4.44 (s, 2H, CH_2)	$C_{14}H_{13}NO_3S$ (275.3)	calc.	C 61.08	H 4.76	N 5.08	S 11.65
			found	61.04	4.95	5.06	11.53

time (Table 1). Work-up was carried out by dilution with water and subsequent filtration of the solid or extraction of the suspension. The product was further purified by crystallization or chromatography over silica gel using dichloromethane or dichloromethane/ethyl acetate as the eluent, followed by crystallization (Table 1). Some characteristic ^{1}H-N.M.R. data and elemental analyses are given in Table 3.

Reaction of 4-Methylphenyl α-Oximinobenzyl Sulfone (3c) with Phosphorus(V) Chloride:

Phosphorus(V) chloride (31 g, 0.15 mol) was added in small portions to a solution of oxime **3c** (27.4 g, 0.1 mol) in ether (200 ml) at 0°. The solution was stirred for 45 min and then poured onto ice. The mixture was extracted with ether, the ethereal extract was washed with water, dried with sodium sulfate, and evaporated. Crystallization of the residue from ether gave *N-tosylbenzimidoyl chloride* (**5**); yield: 16.4 g (0.056 mol, 56%); m.p. 103.5–103.7° (Ref.[22], m.p. 103°).

The product obtained by distillation of the mother liquor of the above recrystallization was analyzed by I.R.- and ^{1}H-N.M.R. spectrometry and by G.L.C. (Varian 1400 with a F.I.D. detector; column: 5′, 1/8″, 3% SE 30 on Faraport 100–120 mesh): *benzonitrile* (35%), *tosyl chloride* (20%), *ethyl tosylate* (13%).

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