Heteroatom Chemistry
Volume 4, Number 2/3, 1993

Facile Reductive Deamination of Arylamines Using a New Arenesulfonyl Nitrite

Hyun Ho Shin, Young Jun Park, and Yong Hae Kim*

Department of Chemistry, Korea Advanced Institute of Science and Technology, 371-1, Kusong Dong, Yusung Gu, Taejon, Korea

Received 28 September 1992

ABSTRACT

Arenesulfonic acids were found to react with dinitrogen tetraoxide at −40°C in tetrahydrofuran to form arenesulfonyl nitrites which showed excellent diazotizing ability for the reductive deaminations of arylamines to arenes in the presence of anhydrous copper(II) halides as catalysts.

INTRODUCTION

Common procedures for the replacement of an aromatic primary amino group by hydrogen involve preliminary diazotization of the aromatic amines followed by reductive substitution by a hydrogen donor, such as hypophosphorous acid [1], silyl, and stannyl hydrides [2]. Later, one-step reductive deamination of aniline derivatives was developed by Cadogan [3] and Doyle [4]. The reductive deaminations were carried out using alkyl nitrites as diazotizing agents and THF or DMF under reflux as a solvent and also as a hydrogen donor.

Earlier, we reported that various arylamines reacted with alkyl thionitrate [5,6] or nitroso sulfone [7] in the presence of anhydrous copper(II) halide to give the corresponding aryl halides. Alkyl nitrite was used as a diazotizing agent in the same reaction [8].

RESULTS AND DISCUSSION

In the course of our investigation on oxidation of sulfur compounds, we have found that arenesulfonic acids react with dinitrogen tetraoxide at −40°C in THF to form arenesulfonyl nitrites which show powerful nitrosating ability on the amino nitrogen. Sulfonyl nitrites have neither been isolated nor their structures confirmed. The formation of 2,4,6-tri-*tert*-butylbenzene- or benzenesulfonyl nitrite, ***2a*** and ***2b***, respectively, has been confirmed by means of their UV spectra taken at low temperature.

The UV absorption spectra of ***2a*** and ***2b*** in THF solution (10^{-2} M) were successfully measured at or near −20°C and compared with those of N_2O_4 (UV of ***2a***: λ_{max} (ϵ), 354 (94); ***2b***: 358 (68); N_2O_4: 350 (69)). Although the nitrites ***2*** could not be isolated due to their instability at room temperature, they were found to be stable enough to use for nitrosation at low temperature. After benzenesulfonic acid and an equivalent amount of dinitrogen tetraoxide had been mixed at −40°C in THF, the arylamine and anhydrous copper(II) chloride were added to this reaction mixture. The reductive deamination took place smoothly *in situ* in a short reaction time to give the corresponding arenes in high yields together with benzenesulfonic acid. The results obtained are summarized in Table 1.

Sulfonyl nitrite is considered to be a better reagent for the reductive deamination than an alkyl nitrite due to easier cleavage of the O–N bond of the sulfonyl nitrite than that of the alkyl nitrite. Copper(II) chloride plays a catalytic role in the reductive deamination. It is noteworthy that, when excess of copper chloride was used with the nitrosating agent, aryl halides were obtained as the main product [5–7]. However, chlorination did not occur when a catalytic amount (0.1 eq) of copper(II) chloride was used. A catalytic role of Cu^{2+} has been well-documented in the Sandmeyer-type reactions [6,9,10]. When 0.1–0.3 equivalent amounts of $CuCl_2$ were used, about the same high yields of bromo-

---

Dedicated to Prof. James Cullen Martin on the occasion of his sixty-fifth birthday.

*To whom correspondence should be addressed.

1042-7163/93/$5.00 + .25

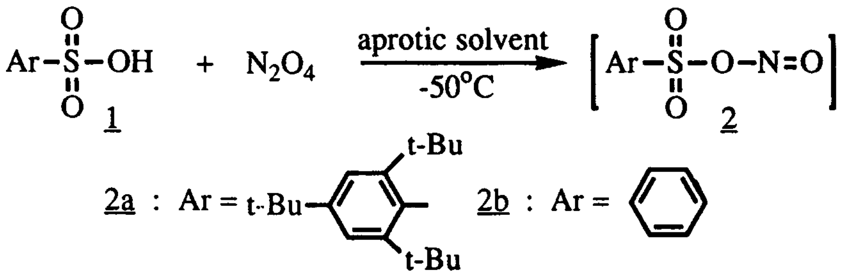
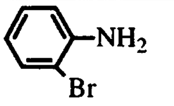
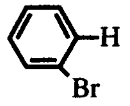
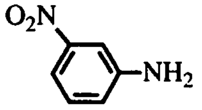
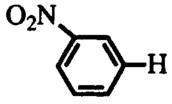
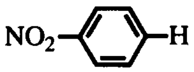
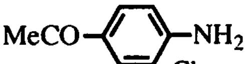
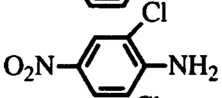
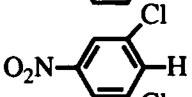
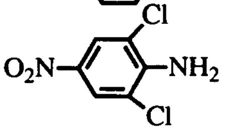
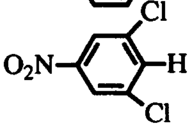
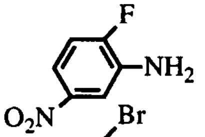
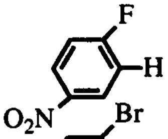
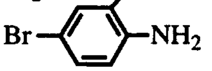
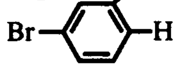
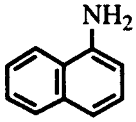
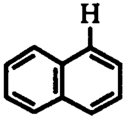
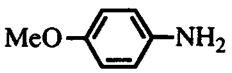
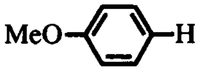


TABLE 1 Deamination Reaction of Arylamines with Benzenesulfonyl Nitrite (*2b*)[a]

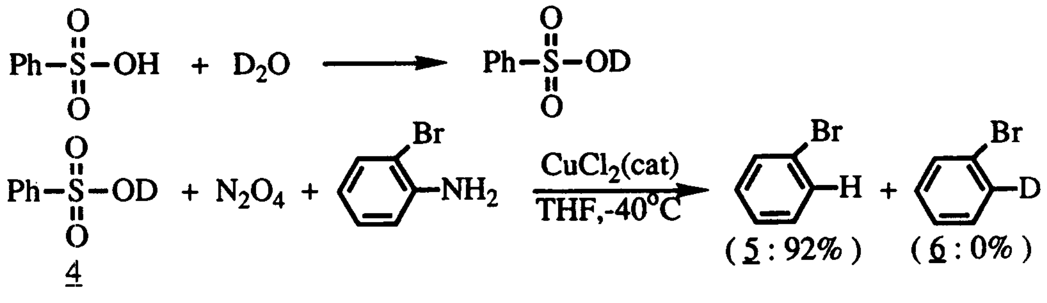
Run	Substrates	$CuCl_2$/Subs. (Molar Ratio)	Time(min)	Products	yield(%)[b]
1		0	0.1		77[c]
2		0.1	0.1		92[c]
3		1.2	0.5		50[d]
4		0.1	0.5		83[c]
5		0.1	0.5		91[c]
6		0.1	1		90[c]
7		0.1	1		87
8		0.1	6		92
9		0.1	0.5		85
10		0.1	0.5		80
11		0.1	0.5		54[c]
12		0.1	3		51[c]

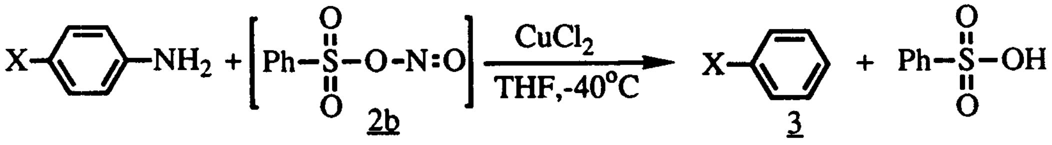
[a] Reaction temperature: −40°C; solvent: THF.

[b] Isolation yield.

[c] The yields were determined by GC.

[d] 2-Chlorobromobenzene was also obtained in 44% yield.





benzene were obtained (run 2 in Table 1). However, as the amount of $CuCl_2$ increases, the yields of bromobenzene decrease together with an increase of the side product 2-chlorobromobenzene.

As shown in Table 1, most of the arylamines were converted into arenes in high yields. The yields of arenes vary depending upon whether the substrates are substituted with electron-withdrawing or electron-releasing groups at the *o*- and *p*-positions. In the case of aryl amines having electron withdrawing groups at *o* or *p* positions, the yields of the products are higher than those obtained from arylamines having electron-donating groups at these positions. For example, *p*-nitroaniline derivatives (runs 1, 5, and 6), *p*-acetylaniline (run 4), and *o*- or *p*-haloanilines (runs 3, 7, and 8) were converted to the corresponding *p*-nitrobenzene derivatives, acetophenone, and *o*- or *p*-halobenzenes, respectively, in excellent yields.

In order to examine solvent effects, various aprotic solvents were examined in the deamination of *o*-bromoaniline. THF and DMF gave the best results, and these data are summarized in Table 2.

Here, a question arises as to whether the newly gained aromatic hydrogen atom originated from the solvent used or from benzenesulfonic acid. Cadogan [3] and Doyle [4] demonstrated that the new hydrogen atom originates from a solvent, such as THF or DMF. Thus, deuterated benzenesulfonic acid (***4***; D content 99 at. %) was prepared and then used for the deamination reactions. The product ***5*** contained H (92% yield) rather than D, which was confirmed by GC-mass spectroscopy (m/z 158, 156 (M^+)). The formation of ***6*** (m/z 159, 157 (M^+)) could not be confirmed. These results obtained from the isotope-labeling experiment indicate that the new aromatic hydrogen originated from the solvent (THF).

The reaction appears to involve a radical process, as in the case of the deamination with an alkyl nitrite [3,4], and to be consummated by hydrogen abstraction from THF by an aryl radical. The reaction mechanism of deamination by benzenesulfonyl nitrite is being investigated.

In conclusion, although arenesulfonyl nitrite is unstable at room temperature, it is a new promising nitrosating reagent for the direct reductive deamination of arylamines, and the arenesulfonyl nitrite-THF system is superior to other known methods in terms of the mild conditions and the high yields.

EXPERIMENTAL

The ^1H NMR spectra were recorded with Varian T-60A, FT-80A, and Bruker AM-300 spectrometers. Infrared spectra were taken on Perkin-Elmer Model 238B and Bomem MB-100 FT-IR spectrometers. Mass spectra were obtained on a Hewlett Packard GC/MS 5985B instrument. Ultraviolet spectra were taken on a Cary Model 17 spectrophotometer. The GC analyses were performed on a Varian Aerograph 2800 instrument and a Model 3700 instrument equipped with flame ionization detector and with nitrogen as a carrier gas with a Varian 4290 integrater.

Preparation of Arenesulfonyl Nitrite

Dinitrogen tetraoxide (1 mmol, 300 μl in CCl_4) was added to a solution of arenesulfonic acid (1 mmol) in dry THF (5 ml) with good stirring at −40°C. The mixture was stirred for several minutes. The colorless solution changed to intense blue. The UV absorption spectra of arenesulfonyl nitrite intermediates (1×10^{-2} M solution) were successfully measured at −20°C using cold nitrogen gas. The UV spectra of the arenesulfonyl nitrite are clearly different from those of dinitrogen tetraoxide, as shown in Figure 1 (***2a***: peaks of fine structure, λ (nm) (ϵ): 319(48), 330(70), 340(91), 354(94), 366(62), 388(16); ***2b***: 330(35), 344(51), 358(68), 371(65), 386(34); N_2O_4: 318(29), 328(46), 339(64), 350(69), 359(69), 372(60), 388(33)).

TABLE 2 Deamination Reaction of *o*-Bromoaniline with Benzenesulfonyl Nitrite in Various Solvents[a]

Solvents	*Product yield* (%)[b]
THF	92
DMF	90
Ether	72
CH_3CN	60
$CHCl_3$	46

[a] Reaction temperature: −40°C; reaction time: 20 minutes Molar ratio: sub.:reagent:cat = 1 : 1.2 : 0.1.

[b] The yields were determined by GC.

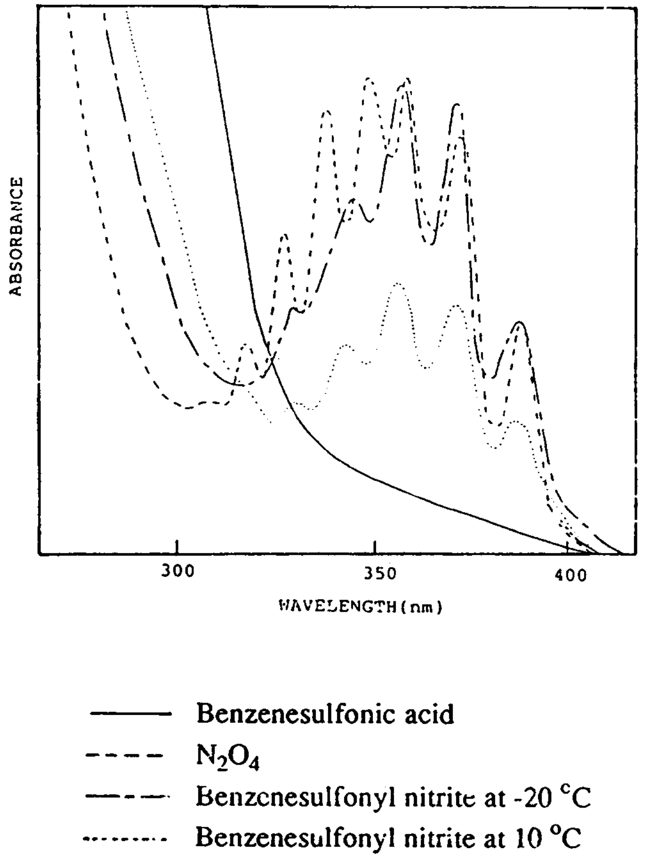


FIGURE 1 The UV spectra of benzenesulfonyl nitrite at low temperature.

Preparation of Benzenesulfonic Acid-d_1

Benzenesulfonic acid (2 mmol, 316 mg) was dissolved in hot deuterium oxide (D_2O 500 μl, 99.8 at. %), and then the solvent was removed *in vacuo*. Five repetitions of the same treatment gave the benzenesulfonic acid-d_1 (>99 at. %). The product obtained was identified by ^{1}H NMR and mass spectroscopy. *Benzenesulfonic acid*: ^{1}H NMR (DMSO-d_6) 5.5 (s, 1H), 7.3–7.9 (m, 5H). *Benzenesulfonic acid-d_1*: ^{1}H NMR (DMSO-d_6) 7.3–7.9 (m, 5H), mass; m/z 159 (M^+).

Reaction of 2,6-Dichloro-4-nitroaniline with Benzenesulfonyl Nitrite

To a solution of benzenesulfonic acid (1.2 mmol, 190 mg) and $CuCl_2$ (0.1 mmol, 13.5 mg) in dry THF (5 ml) was added a solution of N_2O_4 (1.2 mmol, 360 μl in CCl_4) at −40°C under a nitrogen atmosphere. After the mixture had been stirred for 5 minutes, the 2,6-dichloro-4-nitroaniline (1 mmol, 207 mg) in dry THF (5 ml) was added. The reaction was monitored by TLC (Kieselgel 60 F_{254}, Merck, Ether: *n*-Hexane = 1:15). After the reaction was completed, the reaction mixture was treated with saturated Na_2CO_3 solution (5 ml) and extracted with ether. The ether layer was separated, dried over anhydrous magnesium sulfate, and evaporated under reduced pressure. The reaction mixture was separated by preparative TLC (Silica gel, Merck, 60 GF_{254}, Ether: *n*-Hexane = 1:15) to give pure 1,3-dichloro-5-nitrobenzene (177 mg, 92% yield), which was identified by comparing its ^{1}H NMR spectrum and mp with those of the authentic sample; mp = 64–65°C (Ref. [11] 65.4°C).

ACKNOWLEDGMENT

This research was supported by grants from CBM (Korea Science and Engineering Foundation).

REFERENCES

[1] N. Kornblum, *Org. React.*, *2*, 1944, 262.
[2] Y. Nakayama, M. Yoshida, O. Simamura, *Tetrahedron*, *26*, 1970, 4609.
[3] J. I. G. Cadogan, G. A. Molina, *J. Chem. Soc. Perkin Trans. I*, *6*, 1973, 541.
[4] M. P. Doyle, J. F. Dellaria, Jr., B. Siegfried, S. W. Bisop, *J. Org. Chem.*, *42*, 1977, 3494.
[5] S. Oae, K. Shinhama, Y. H. Kim, *Bull. Chem. Soc. Jpn.*, *53*, 1980, 1065.
[6] S. Oae, K. Shinhama, Y. H. Kim, *Tetrahedron Lett.*, 1978, 4519.
[7] S. Oae, K. Shinhama, K. Fujimori, Y. H. Kim, *Bull. Chem. Soc. Jpn.*, *53*, 1980, 775.
[8] M. P. Doyle, B. Siegfried, J. F. Dellaria, Jr., *J. Org. Chem.*, *42*, 1977, 2426.
[9] C. Galli, *Chem. Rev.*, *88*, 1988, 6765.
[10] A. F. Hegarty: in S. Patai, (ed): *The Chemistry of Diazonium and Diazo Groups*, Wiley, New York, part 2, ch. 12, p. 511 (1978).
[11] C. B. Kremer, *J. Am. Chem. Soc.*, *61*, 1939, 2658.