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SYNTHESIS AND TAUTOMERISM OF 1-ARYLSULFONAMIDO-1-METHYLTHIO-2-NITROETHYLENES: CONVERSION TO N-ARYLSULFONYL NITROACETAMIDES

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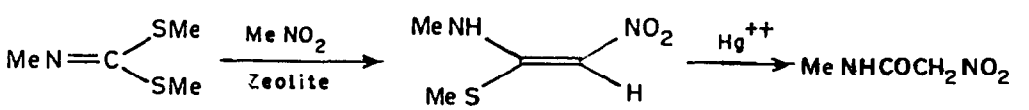
Abstract: N-Arylsulfonyl carbonimidodithioic acid dimethyl ester has been reacted with nitroalkanes to generate the corresponding 1-alkylthio-1-aryl sulfonamido-2-nitroethylenes; the latter have been hydrolysed to N-arylsulfonyl-2-nitroacetamides. Solvent dependent imine-enamine tautomerism is observed in the nitroenamines 2a-d.

The application of carbonimidodithioates in synthesis has been the subject of several recent studies[1]. Although such substrates have been reported earlier to react with several active methylene compounds[2] (carbon nucleophiles), the reaction with nitromethane to produce nitroenamines had not been described in the literature. The first such synthesis of a nitroenamine by the reaction of N-methyl carbonimidodithioic acid dimethyl ester with nitromethane in the presence of a zeolite catalyst (Scheme I) was recently reported by us[3]. Subsequently we have established that such 1-substituted amino-1-methylthio-2-nitroethylenes can be hydrolytically converted to N-substituted nitroacetamides[4].

SCHEME-1.



The present report deals with an extension of the above approach to the synthesis of the hitherto unknown N-arylsulfonyl nitroacetamides. This validates the generality of such a synthetic route to nitroacetamides, a class of compound for which

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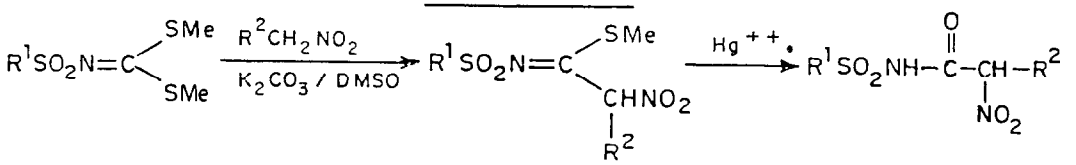
there are very few general syntheses available. The conversion of nitroacetic ester to the corresponding amides by reaction with amines needs harsh conditions and leads to only moderate yields[5,6]. The reason for this is the high acidity of nitroacetic ester (pKa 5.62)leading to salt formation with the amine. Two other methods for the preparation of specific nitroacetamides hardly come under the description of general syntheses. These are: (i) nitration of preformed amide[7] and (ii)generation of nitroacetyl chloride from nitryl chloride and ketene, and its trapping with amines[8]. Our method, therefore, appears to be the only general synthetic route for a wide variety of substituted nitroacetamides.

Results and Discussion

N-Arylsulfonyl carbonimidodithioic acid dimethyl esters (1) were prepared by the standard procedure from the corresponding sulfonamides[9]. To our initial disappointment, these could not be induced to react with nitromethane by zeolite catalysis. Possibly the size of the molecule and its consequent inability to enter the zeolite cavity were responsible for this failure. However, these carbonimidodithioates

SCHEME-2.



1a–c	2a–h	3a–h
1a $R^1=C_6H_5$	2a, 3a $R^1=C_6H_5$;	$R^2=H$
1b $R^1=4\text{-Me}-C_6H_4$	2b, 3b $R^1=4\text{-Me}-C_6H_4$;	$R^2=H$
1c $R^1=4\text{-OMe}-C_6H_4$	2c, 3c $R^1=4\text{-OMe}-C_4H_4$;	$R^2=H$
1d $R^1=4\text{-Cl}-C_6H_4$	2d, 3d $R^1=4\text{-Cl}-C_6H_4$;	$R^2=H$
1e $R^1=2$-thienyl	2e, 3e $R^1=2$-thienyl ;	$R^2=H$
	2f, 3f $R^1=C_6H_5$;	$R^2=Me$
	2g, 3g $R^1=4\text{-OMe}-C_6H_4$;	$R^2=Me$
	2h, 3h $R^1=4\text{-Cl}-C_6H_4$;	$R^2=Me$

reacted easily with nitromethane and nitroethane in DMSO solution in presence of

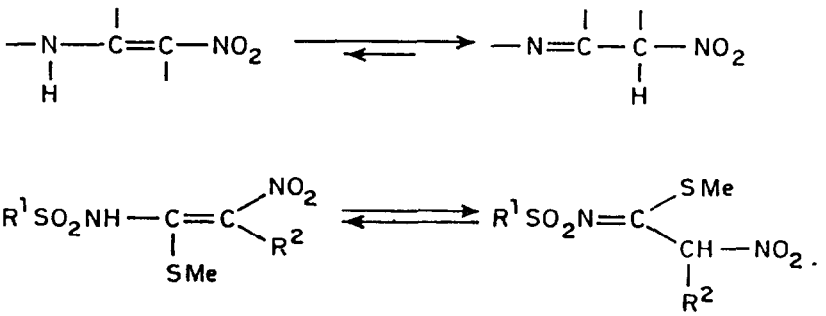
anhydrous potassium carbonate to furnish a series of 1-arylsulfonylimino-1-methylthio-2-nitroethanes (2) (Scheme 2). The structures of the products were proved by NMR and IR spectral data. However, the secondary nitro compound 2-nitropropane failed to react with(1)under these conditions.

The hydrolysis of the above compounds (2) could be easily achieved in aqueous acetonitrile in the presence of mercuric chloride. This led to N-arylsulfonyl nitroacetamides (3) in moderate to good yields.

Tautomerism in compounds 2

The phenomenon of tautomerism in nitroenamines (having an NH group) has been exhaustively discussed[10]. Of the three possible tautomers, there has been no evidence for the nitronic acid. A few instances of imine-enamine tautomerism in substituted nitroenamines have been reported[11,12]. However, by and large, it appears that the enamine form represents the thermodynamically more stable tautomer (Scheme 3).

SCHEME-3.



4 2

We now find that the compounds 2a-d exhibit solvent dependent tautomerism, as determined by ^1H NMR and UV spectroscopy. It turns out that in non-polar solvents (CCl_4, $CDCl_3$), these compounds exist almost completely in the imine form (2) whereas in polar solvents (DMSO, MeOH) the enamine form 4 predominates. Thus the ^1H NMR spectrum of 2d in $CDCl_3$ and CCl_4 shows a two-proton singlet at 5.7 δ and no signal corresponding to $C{=}CHNO_2$. In DMSO-d_6, on the other hand, it exhibits a one proton singlet at 6.0 δ which can be ascribed to the vinyl proton of the enamine

tautomer 4d. These assignments are further confirmed by UV spectroscopy. In $CHCl_3$, the compound shows only a weak absorption band at 364 nm (ϵ ,600) whereas in methanol, the absorption at 364 nm (ϵ , 6,200) is very strong. This agrees well with Büchi's earlier observations[11]. Similar observations were made with compounds 2a-c whereas the methyl substituted derivatives 2f-h exist in the imine form even in polar solvents as shown by both ^1H NMR and UV spectroscopy.

Experimental

Infrared spectra were obtained on a Perkin-Elmer 599B spectrophotometer. ^1H NMR spectra were recorded on a Jeol-FMX 60S, Varian FT-80A, or Bruker WH-90 spectrometer with tetramethylsilane as internal standard. UV spectra were recorded on a Hitachi 330 spectrophotometer. Mass spectra were measured on a GCMS Finnigan MAT 1020c spectrophotometer. N-Arylsulfonyl carbonimidodithioic acid dimethyl esters 1a-e were prepared by the reported procedure[9].

General procedure for the reaction of nitroalkanes with N-arylsulfonyl crbonimidodithioic acid dimethyl ester (1a-e):

To a stirred suspension of potassium carbonate (60 mmol) in dimethylsulfoxide (40 ml) the nitroalkane (30 mmol) was added slowly at room temperature. This mixture was stirred for 15 min. N-Arylsulfonyl carbonimidodithioic acid dimethyl ester (20 mmol) was then added to the mixture in small portions with efficient stirring. The mixture was stirred at room temperature for 5 hrs. The colour of the reaction mixture became orange. The mixture was poured over crushed ice and acidified with 1N HCl and extracted with chloroform (3x50ml). The chloroform layer was washed with water (2x50 ml) and dried over anhydrous sodium sulfate. The solvent was removed by distillation to afford the nitro compounds (2a-h). The nitro compounds so obtained were purified by recrystallisation or column chromatography.

1-Methylthio-1-phenylsulfonylimino-2-nitroethane (2a) :

Yield, 77%; thick oil; IR (nujol): 1580, 1550, 1480 cm^{-1}; ^1H NMR ($CDCl_3$):δ2.43 (s, 3H, $-SCH_3$), 5.7 (s, 2H, $-CH_2$); 7.4-7.7 (m, 3H, Ar-H), 7.8-8.0 (m, 2H, Ar-H); UV ($CHCl_3$): λ max 273 nm (ϵ , 14,400), 350 nm (ϵ ,1,200); (MeOH) λ max 273 nm (ϵ , 15,600), 365 nm (ϵ , 19,800). Anal. Calcd. for $C_9H_{10}N_2O_4S_2$: C, 39.4; H, 3.7;

N, 10.2. Found: C, 39.6; H, 3.9; N, 10.6.

1-[(4-Methylphenyl)sulfonylimino]-1-methylthio-2-nitroethane (2b):

Yield, 91%; mp. 63°C; IR(nujol): 1550, 1540, 1410 cm^{-1}; ^1H NMR ($CDCl_3$):δ2.4 (s,6H, $-SCH_3$, -CH3), 5.66 (s, 2H, $-CH_2$), 7.23 (d, 2H, Ar-H, J = 8Hz), 7.73 (d, 2H, Ar-H, J = 8Hz); (DMSO-d_6):δ 2.35 (s, 6H, $-SCH_3$, $-CH_3$), 6.05 (s, 1H, -CH), 7.35 (d, 2H,Ar-H, J = 8Hz), 7.71 (d, 2H, Ar-H, J = 8Hz); UV ($CHCl_3$): λ max 275 nm (ε , 15,300), 350 nm (ε , 1,500); (MeOH): λ max 275 nm (ε , 10,800), 365 nm (ε , 6.300). Anal. Calcd for $C_{10}H_{12}N_2O_4S_2$: C, 41.6; H, 4.2; N, 9.7. Found: C, 41.7; H, 4.4; N, 9.3.

1-[(4-Methoxyphenyl)sulfonylimino]-1-methylthio-2-nitroethane (2c):

Yield, 78%; mp. 121°C; IR (nujol): 1565, 1500, 1420 cm^{-1}; ^1H NMR ($CDCl_3$):δ 2.4 (s, 3H, $-SCH_3$), 3.86 (s, 3H, $-OCH_3$), 5.68 (s, 2H, $-CH_2$), 7.0 (d, 2H, Ar-H, J = 8Hz), 7.86 Id, 2H, Ar-H, J = 8Hz); (DMSO-D6):δ 2.44 (s, 3H, $-SCH_3$), 3.82 (s, 3H, $-OCH_3$), 6.0 (s, 1H, -CH), 7.06 (d, 2H, Ar-H, J = 8Hz), 7.7 (d, 2H, Ar-H, J = 8Hz); UV ($CHCl_3$): λ max 278 nm (ε , 14,200), 350 nm (ε , 1,300); (MeOH): λ max 278 nm (ε , 14,700), 362 nm (ε , 5,000). Anal.Calcd. for $C_{10}H_{12}N_2O_5S_2$: C, 39.5; H, 4.0; N, 9.2. Found : C, 39.7; H, 4.2; N, 9.3.

1-[(4-Chlorophenyl)sulfonylimino]-1-methylthio-2-nitroethane(2d):

Yield, 76%; mp. 136°C; IR (nujol): 1585, 1555 cm^{-1}; ^1H NMR ($CDCl_3$): δ 2.46(s, 3H, $-SCH_3$), 5.7 (s, 2H, $-CH_2$), 7.43 (d, 2H, Ar-H, J = 8Hz), 7.9 (d, 2H, Ar-H, J = 8Hz); (DMSO-d_6): δ 2.33, (bs, 3H, $-SCH_3$), 6.0 (s, 1H, -CH), 7.55 (d, 2H, Ar-H, J = 8Hz), 7.8 (d, 2H, Ar-H, J = 8Hz); UV ($CHCl_3$): λ max 275 nm (ε , 14,600), 364 nm (ε , 600); (MeOH): λ max 275 nm (ε , 12,000), 364nm (ε , 6.200). Anal. Calcd. for $C_9H_9ClN_2O_4S_2$: C, 35.0; H, 2.9; N, 9.0 Found : C, 35.1; H, 3.2; N, 9.2.

1-Methylthio-1-[(2-thienyl)sulfonylimino]-2-nitroethane (2e):

Yield, 90%; thick oil; IR (nujol): 1550, 1440, 1230 cm^{-1}; ^1H NMR ($CDCl_3$):δ 2.5 (s, 3H, $-SCH_3$), 5.66 (s, 2H, $-CH_2$), 7.0-7.23 (m, 1H, Ar-H), 7.5-7.7 (m, 2H, Ar-H). Anal.Calcd for $C_7H_8N_2O_4S_3$: C, 30.0; H, 2.9. Found: C, 30.0; H, 3.4.

1-Methylthio-1-phenylsulfonylimino-2-nitropropane (2f):

Yield, 70%, Thick oil; IR (nujol): 1560, 1320 cm^{-1}; ^1H NMR ($CDCl_3$):δ 1.88 (d, 3H, $-CH_3$, J = 7Hz), 2.31 (s, 3H, $-SCH_3$), 6.56 (q, 1H, -CH, J = 7Hz), 7.35-7.68 (m, 3H,

Ar-H), 7.8-8.0 (m, 2H, Ar-H). (DMSO-d_6) :δ 1.75 (d, 3H, $-CH_3$, J = 7Hz), 2.48 (s, 3H, $-SCH_3$), 6.40 (q, 1H, -CH, J = 7Hz), 7.5-7.66(m, 3H, Ar-H), 7.78-8.0 (m, 2H, Ar-H); UV ($CHCl_3$): λ max 270 nm (ϵ , 29,900); (MeOH): λ max 270 nm (ϵ , 11,600). Anal.Calcd. for $C_{10}H_{12}N_2O_4S_2$: C, 41.6; H, 4.2; N, 9.7. Found: C, 42.1; H, 4.6; N, 9.3.

1-[(4-Methoxyphenyl)sulfonylimino]-1-methylthio-2-nitropropane(2g):

Yield, 70%; thick oil; IR(nujol) : 1550, 1480, 1310 cm^{-1}; ^1H NMR ($CDCl_3$): δ 1.88, (d, 3H, $-CH_3$, J = 7Hz), 2.31 (s, 3H, $-SCH_3$), 3.84 (s, 3H, $-OCH_3$), 6.62 (q, 1H, -CH, J = 7Hz), 6.94 (d, 2H, Ar-H, J = 8Hz), 7.89 (d, 2H, Ar-H, J = 8Hz). Anal.Calcd. for $C_{11}H_{14}N_2O_5S_2$: C, 41.5; H, 4.4. Found : C, 42.1; H, 4.7.

1-[(4-chlorophenyl)sulfonylimino]-1-methylthio-2-nitropropane(2h) :

Yield, 85%; mp. 65°C; IR (nujol); 1550, 1510, 1300 cm^{-1}; ^1H NMR ($CDCl_3$): δ 1.9 (d, 3H, $-CH_3$, J = 8Hz), 2.33 (s, 3H, $-SCH_3$), 6.53 (q, 1H, -CH, J = 8Hz), 7.44 (d, 2H, Ar-H, J = 9Hz), 7.8 (d, 2H, Ar-H, J = 9Hz). Anal. Calcd. for $C_{10}H_{11}ClN_2O_4S_2$: C , 37.2; H, 3.5. Found : C, 36.9; H, 3.3.

General procedure for Hg^{2+} catalysed hydrolysis of 1-Arylsulfonylimino-1-methylthio-2-nitro-alkanes (2a-h);

To the solution of mercuric chloride (5.6 mmol) in acetonitrile (32 ml) and water (8 ml) was added under stirring, the solution of 1-arylsulfonylimino-1-methylthio-2-nitro alkane (2a-h, 5.0 mmol) in acetonitrile (5 ml). The reaction mixture was stirred at room temperature overnight. The mercury salt was removed by filtration and the filtrate was concentrated under reduced pressure. The residue was extracted with ethyl acetate. The solvent was removed to get N-arylsulfonyl nitro-acetamide. It was further purified by column chromatography. The analytically pure samples were prepared by recrystallisation from either ethyl acetate- pet ether or methanol-chloroform mixture.

N-Phenylsulfonyl-2-nitroacetamide (3a) :

Yield, 75%; mp 168-170°C; IR (nujol): 3160, 1720, 1565 cm^{-1}; ^1H NMR (DMSO-d_6): δ 5.44 (s, 2H, $-CH_2$), 7.5-7.7 (m, 3H, Ar-H), 7.8-8.0 (m, 2H, Ar-H); MS (m/z): 180 (39), 141(63), 77(100). Anal.Calcd. for $C_8H_8N_2O_5S$: C, 39.3; H, 3.3; N, 11.5. Found: C, 39.9; H, 3.5; N, 11.2.

N-[(4-Methylphenyl)sulfonyl]-2-nitroacetamide (3b) :

Yield, 75%; mp. 165°C; IR (nujol): 3240, 1720, 1600, 1560, 1550 cm^{-1}; ^1H NMR ($CDCl_3$ + TFA) : δ 2.5 (s, 3H, $-CH_3$), 5.25 (s, 2H, $-CH_2$), 7.38 (d, 2H, Ar-H, J = 9Hz), 7.87 (d, 2H, Ar-H, J = 9Hz). Anal. Calcd. for $C_9H_{10}N_2O_5S$: C, 41.9; H, 3.9; N, 10.8. Found: C, 42.1; H, 3.7; N, 10.3.

N-[(4-Methoxyphenyl)sulfonyl]-2-nitroacetamide (3c) :

Yield, 60%; mp. 155°C; IR (nujol): 3220, 1700, 1600, 1555 cm^{-1}; ^1H NMR (DMSO-d_6):δ 3.8 (s, 3H, $-OCH_3$), 5.4 (s, 2H, $-CH_2$), 7.11 (d, 2H, Ar-H, J = 9Hz), 7.84 (d, 2H, Ar-H, J = 9Hz): MS (m/z): 274 (45), 210 (19), 171 (72), 124 (100), 107 (66). Anal. Calcd. for $C_9H_{10}N_2O_6S$: C, 39.4; H, 3.7. Found: C, 39.7; H, 3.9.

N-[(4-Chlorophenyl)sulfonyl]-2-nitroacetamide (3d) :

Yield, 75%; mp. 162°C; IR (nujol); 3180, 1700, 1550 cm^{-1}; ^1H NMR (DMSO-d_6):δ 5.44 (s, 2H, $-CH_2$), 7.7 (d, 2H, Ar-H, J = 8Hz), 7.9 (d, 2H, Ar-H, J = 8Hz). Anal.Calcd for $C_8H_7ClN_2O_5S$: C, 34.5; H, 2.5; N, 10.1. Found: C, 34.6; H, 2.8; N, 9.8.

N-(2-Thienylsulfonyl)-2-nitroacetamide (3e) :

Yield, 75%; mp. 158°C; IR (nujol): 3165, 1710, 1565 cm^{-1}; ^1H NMR (DMSO-d_6 + $CDCl_3$):δ 5.31 (s, 2H, $-CH_2$), 7.06-7.2 (m, 1H, Ar-H), 7.76-7.9 (m, 2H, Ar-H). Anal.Calcd. for $C_6H_6N_2O_5S_2$: C, 28.8; H, 2.4. Found C, 29.1,H, 2.8.

N-Phenylsulfonyl-2-nitropropionamide (3f) :

Yield, 62%, mp. 82°C; IR (nujol): 3220, 1720, 1540 cm^{-1}; ^1H NMR ($CDCl_3$ + TFA):δ 1.68 (d, 3H, $-CH_3$, J = 8Hz), 5.11 (q, 1H, -CH, J = 8Hz), 7.37-7.7 (m, 3H, Ar-H), 7.8-8.0 (m, 2H, Ar-H). Anal. Calcd for $C_9H_{10}N_2O_5S$: C, 41.9; H, 3.9; N, 10.8. Found : C, 42.2, H, 4.3; N, 10.4.

N-[(4-Methoxyphenyl)sulfonyl]-2-nitropropionamide (3g) :

Yield, 69%; mp. 127°C; IR (nujol) 3200, 1720, 1550 cm^{-1}; ^1H NMR ($CDCl_3$ + TFA):δ 1.73 (d, 3H, $-CH_3$, J = 7Hz), 3.88 (s, 3H, $-OCH_3$), 5.17 (q, 1H, -CH, J = 7Hz), 7.0 (d, 2H, Ar-H, J = 10Hz), 7.9 (d, 2H, Ar-H, J = 10 Hz). Anal. Calcd. for $C_{10}H_{12}N_2O_6S$. C, 41.6; H, 4.2. Found : C, 41.1; H, 4.3.

N-[(4-Chlorophenyl)sulfonyl]-2-nitropropionamide (3h) :

Yield, 74%; mp. 135°C; IR (nujol):3200, 1710, 1550 cm^{-1}; ^1H NMR ($CDCl_3$ + TFA):δ 1.70 (d, 3H, $-CH_3$, J = 7Hz), 5.15 (q, 1H, -CH, J = 7Hz), 7.57 (d, 2H, Ar-H, J =

8Hz), 7.95 (d, 2H, Ar-H, J = 8Hz). Anal. Calcd. for $C_9H_9ClN_2O_5S$: C, 36.9; H, 3.1. Found : C, 36.6; H, 3.3.

REFERENCES

1. Pooranchand, D.; Ila, H.; Junjappa,H., Synthesis, 1987, 1136 and references cited therein; Alvaraz-Ibarra, C.; Davila, E.; Mateo, A.; Ortiz, P. and Quiroga, M.L., Tetrahedron Lett., 1987, 28, 6667.

2. Metzger, C.; Wegler, R., Chem.Ber., 1968, 101, 1131.

3. Deshmukh, A.R.A.S.; Reddy, T.I.; Bhawal,B.M.; Shiralkar, V.P. and Rajappa,S., J.Chem.Soc.Perkin.Trans.I, 1990, 1217.

4. Manjunatha, S.G.; Reddy, K.V. and Rajappa, S., Tetrahedron Lett., 1990, 31, 1327.

5. Shipchandler, M.T., Synthesis, 1979, 606.

6. Ciommer, B.; Frenking, G.and Schwarz, H., Chem.Ber., 1981, 114, 1503.

7. Feuer, H.; Panda, C.S.; Hou, L. and Bevinakatti, H.S., Synthesis, 1983, 187.

8. Steinkopf, W. and Kuhnel, M., Chem.Ber., 1942, 75B, 1323.

9. Compper, R. and Hagele, W., Chem.Ber., 1966, 99, 2885.

10 Rajappa, S., Tetrahedron, 1981, 37, 1453.

11 Büchi, G. and Wuest, H., J.Org.Chem., 1979, 44, 4116.

12 Hamberger, H.; Reinshage, H.; Schulz, G. and Sigmund, G., Tetrahedron.Lett., 1977, 41, 3619.