Available online at www.sciencedirect.com
ScienceDirect
Mendeleev Commun., 2005, 15(5), 200–202
Mendeleev Communications

Synthesis of 4-substituted 6-dinitrobenzo[*d*]isothiazoles from 2,4,6-trinitrotoluene

Oleg Yu. Sapozhnikov, Elena V. Smirnova, Mikhail D. Dutov, Vadim V. Kachala and Svyatoslav A. Shevelev*

N. D. Zelinsky Institute of Organic Chemistry, Russian Academy of Sciences, 119991 Moscow, Russian Federation.
Fax: +7 095 135 5328; e-mail: Shevelev@.ioc.ac.ru

DOI: 10.1070/MC2005v015n05ABEH002128

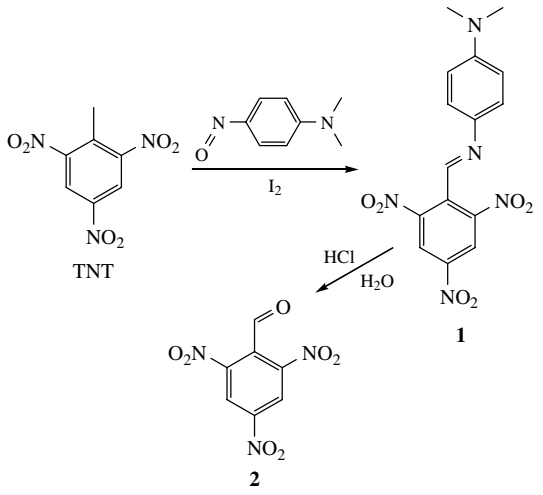
The synthesis of 4,6-dinitrobenzo[*d*]isothiazole from a product obtained by the replacement of the *ortho*-NO_2 group in *N*-2,4,6-trinitrobenzylidene-4′-*N*,*N*-dimethylaminoaniline on treatment with $PhCH_2SH$ was developed.

The aim of this study on the chemistry of 2,4,6-trinitrotoluene (TNT) was to use TNT as a versatile and accessible raw chemical.[1,2] Previously, we synthesised the derivatives of 4,6-dinitrobenzo[*b*]thiophene[3] and 4,6-dinitrobenzo[*d*]isothiazolium salts[4] from TNT. The synthesis involves the preliminary conversion of the TNT methyl group into groups with C=C or C=N double bonds, the selective replacement of the *ortho*-NO_2 group by treatment with $PhCH_2SH$ in the presence of bases to give *ortho*-$PhCH_2S$ derivatives, and the treatment with SO_2Cl_2. The resulting derivatives *ortho*-SCl add *in situ* to a double bond (C=C or C=N) to give the above compounds.

It is well known[5,6] that TNT undergoes condensation at the methyl group with 4-nitroso-*N*,*N*-dimethylaniline to give *N*-2,4,6-trinitrobenzylidene-4′-*N*,*N*-dimethylaminoaniline **1**; the hydrolysis of this compound results in 2,4,6-trinitrobenzaldehyde (TNBA) **2** (Scheme 1).

We studied the reaction of TNBA with benzylmercaptane in *N*-methylpyrrolidone (N-MP) in the presence of K_2CO_3 (Scheme 2). In addition to replacement products **3a** and **3b** (according to ^{1}H NMR data, the **3a**/**3b** ratio is 5:2),† we also observed the products of replacement of two nitro groups, which complicate the separation considerably. Crystallization from an ethanol–acetonitrile mixture (1:1) allowed us to isolate sulfide **3a** in 12% yield.

Sulfide **3a** can be synthesised by preliminary substitution of the nitro group in compound **1** on treatment with $PhCH_2SH$.[4] This results in compounds **4a** and **4b** in a 3:1 ratio. The hydrolysis of a mixture of these compounds resulted in compounds **3a** and **3b** in a ratio of 3:1 (Scheme 2); the final mixture did not contain products of substitution of two nitro groups, and the fraction of compound **3a** was higher than that in the experiment with TNBA. Crystallization from an ethanol–acetonitrile mixture

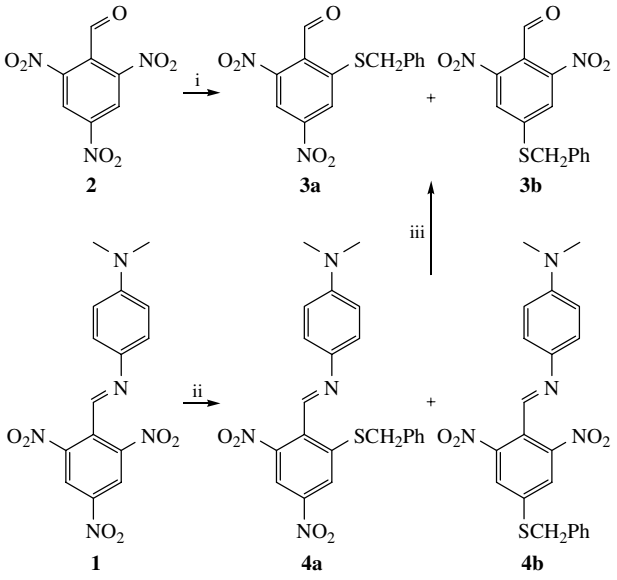


Scheme 1

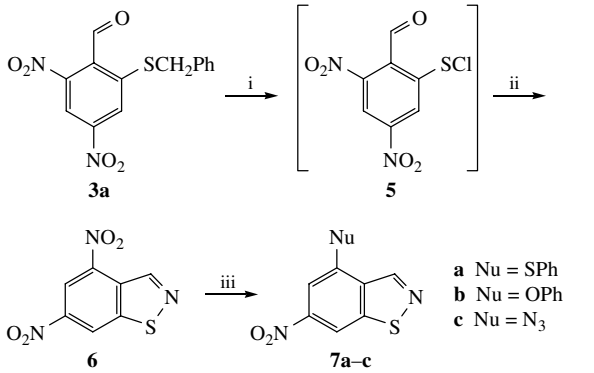
(1:1) gave sulfide **3a** in 40% yield.

The reaction of **3a** with SO_2Cl_2 in dichloroethane resulted in the cleavage of the S-CH_2Ph bond to give sulfenyl chloride **5** (Scheme 3), which was used in the reaction with a 20% solution of ammonia in methanol[7] without additional purification. 4,6-Dinitrobenzo[*d*]isothiazole **6** was the only product of this reaction (Scheme 3).‡

We studied the reactions of 4,6-dinitrobenzo[*d*]isothiazole **6** with various anionic nucleophiles. For example, the reaction of compound **6** with thiophenol in N-MP in the presence of K_2CO_3 at 20 °C gave a single product of the replacement of a nitro group. According to NMR data (NOE), this is a product of replacement of the 4-NO_2 group. The reaction of compound **6** with phenol also resulted in a replacement product of the 4-NO_2 group (NMR data, NOE), but this reaction required a higher temperature (90 °C). The same result was observed in the reaction of compound **6** with sodium azide at 20 °C in DMF. Thus, the regioselective replacement of the 4-NO_2 group is typical of the reactions of 4,6-dinitrobenzo[*d*]isothiazole **6** with anionic nucleophiles.



Scheme 2 *Reagents, conditions and results*: i, 0.01 mol $PhCH_2SH$ + 0.01 mol K_2CO_3, 15 ml N-MP, 20 °C, 2 h [yield of **3a** + **3b**, 84% (5:2)]; ii, 0.01 mol $PhCH_2SH$ + 0.01 mol K_2CO_3, 15 ml N-MP, 20 °C, 3 h [yield of **4a** + **4b**, 92% (3:1)]; iii, 2 g of **4a** + **4b**, 30 ml conc. HCl, 90 °C, 1 h [yield of **3a** + **3b**, 87% (3:1)].



Scheme 3 *Reagents, conditions and results*: i, 2 equiv. SO_2Cl_2, $ClCH_2CH_2Cl$, 20 °C, 30 min; ii, 10 equiv. NH_3 (30% in MeOH); THF, 20 °C, 10 min (yield of **6**, 54%); iii, (*a*) 0.01 mol PhSH + 0.01 mol K_2CO_3, 10 ml N-MP, 20 °C, 5 h (yield of **7a**, 62%); (*b*) 0.01 mol PhOH + 0.01 mol K_2CO_3, 10 ml N-MP, 90 °C, 9 h (yield of **7b**, 41%); (*c*) 0.01 mol NaN_3, 10 ml DMF, 20 °C, 24 h (yield of **7c**, 58%).

One should pay attention to how readily the 4-NO_2 group is replaced in 4,6-dinitrobenzo[*d*]isothiazole **6** even in the absence of electron-withdrawing groups in the isothiazole fragment. Previously, only 4,6-dinitrobenzo[*d*]isothiazoles with a substituent at the 3-position, namely, 4,6-dinitrobenzo[*d*]isothiazol-3-one and 3-chloro-4,6-dinitrobenzo[*d*]isothiazole were described.[8,9] The first member of the series, *i.e.*, nonsubstituted 4,6-dinitrobenzo[*d*]isothiazole **6**, as well as products of the nucleophilic substitution of the 4-NO_2 group in this compound, *i.e.*, compounds **7**, have not been known before.

† ^{1}H NMR spectra were recorded on a Bruker AM-300 instrument. Chemical shifts are reported relative to TMS. The melting points of the resulting compounds were determined on a Boetius hot stage according to Koffler (the heating rate was 4 K min^{-1}).

3a: mp 100–102 °C (MeCN–EtOH). ^{1}H NMR ($CDCl_3$) δ: 10.22 (s, 1H, CHO), 8.61 (d, 1H, arom., ^4J 2.0 Hz), 8.46 (d, 1H, arom., ^4J 2.0 Hz), 7.31–7.26 (m, 5H, Ph), 4.29 (s, 2H, CH_2). Found (%): C, 52.51; H, 2.98; N, 8.63; S, 9.77. Calc. for $C_{14}H_{10}N_2O_5S$ (%): C, 52.83; H, 3.17; N, 8.80; S, 10.07.

6: mp 119–121 °C (EtOH). ^{1}H NMR ([$^2H_6$]DMSO) δ: 9.77 (d, 1H, arom., ^4J 1.9 Hz), 9.72 (s, 1H, CH), 8.95 (d, 1H, arom., ^4J 1.9 Hz). MS, *m*/*z*: 225 [M$^+$]. Found (%): C, 37.52; H, 1.25; N, 18.81; S, 14.01. Calc. for $C_7H_3N_3O_4S$ (%): C, 37.34; H, 1.34; N, 18.66; S, 14.24.

7a: mp 92–94 °C (MeCN–EtOH). ^{1}H NMR ([$^2H_6$]DMSO) δ: 9.30 (s, 1H, CH), 9.16 (d, 1H, arom., ^4J 1.9 Hz), 7.74 (d, 1H, arom., ^4J 1.9 Hz), 7.61–7.48 (m, 5H, Ph). MS, *m*/*z*: 288 [M$^+$]. Found (%): C, 53.86; H, 2.63; N, 9.49; S, 21.87. Calc. for $C_{13}H_8N_2O_2S_2$ (%): C, 54.15; H, 2.80; N, 9.72; S, 22.24.

7b: mp 87–89 °C (EtOH). ^{1}H NMR ([$^2H_6$]DMSO) δ: 9.32 (s, 1H, CH), 8.97 (d, 1H, arom., ^4J 1.9 Hz), 7.62–7.51 (m, 2H, Ph), 7.41–7.26 (m, 4H, Ph + arom.). MS, *m*/*z*: 272 [M$^+$]. Found (%): C, 57.42; H, 2.84; N, 10.44; S, 11.55. Calc. for $C_{13}H_8N_2O_3S$ (%): C, 57.34; H, 2.96; N, 10.29; S, 11.78.

7c: mp 156–159 °C (MeCN–EtOH). ^{1}H NMR ([$^2H_6$]DMSO) δ: 9.19 (s, 1H, CH), 9.04 (d, 1H, arom., ^4J 1.9 Hz), 8.03 (d, 1H, arom., ^4J 1.9 Hz). Found (%): C, 37.74; H, 1.06; N, 31.38; S, 14.70. Calc. for $C_7H_3N_5O_2S$ (%): C, 38.01; H, 1.37; N, 31.66; S, 14.50.

‡ $PhCH_2SH$ (0.01 mol) was added to a mixture of compound **1** (0.01 mol) and K_2CO_3 (0.01 mol) in 15 ml of N-MP at 20 °C with stirring. After stirring for 3 h at ~20 °C, the mixture was poured into water; the precipitate formed was filtered off and dried. The resulting mixture of compounds **4a** and **4b** was placed in 30 ml of concentrated HCl and heated for 1 h at 90 °C. After cooling, the resulting precipitate was filtered off and recrystallised from an EtOH–MeCN mixture (1:1). The yield of compound **3a** was 40%.

SO_2Cl_2 (0.02 mol) was added to sulfide **3a** (0.01 mol) in 10 ml of $ClCH_2CH_2Cl$. The solution was kept for 30 min at room temperature. The solvent and an excess of SO_2Cl_2 were removed *in vacuo*. The resulting oil was dissolved in 15 ml of THF; after that, a 30% NH_3 solution in MeOH (2 ml) was added to the solution. After 10 min, the mixture was poured into water; the resulting precipitate was filtered off and purified by column chromatography (silica gel, $CHCl_3$).

References

1 V. A. Tartakovsky, S. A. Shevelev, M. D. Dutov, A. Kh. Shakhnes, A. L. Rusanov, L. G. Komarova and A. M. Andrievsky, in *Conversion Concepts for Commercial Applications and Disposal Technologies of Energetic Systems*, ed. H. Krause, Kluwer Academic Publishers, Dordrecht, 1997, pp. 137–149.

2 S. A. Shevelev, V. A. Tartakovsky and A. L. Rusanov, in *Combustion of Energetic Materials*, eds. K. K. Kuo and L. T. DeLuca, New York, Begell House, Inc., 2002, p. 62.
3 O. Yu. Sapozhnikov, V. V. Mezhnev, M. D. Dutov, V. V. Kachala and S. A. Shevelev, *Mendeleev Commun*., 2004, 27.
4 O. Yu. Sapozhnikov, V. V. Mezhnev, E. V. Smirnova, B. G. Kimel, M. D. Dutov and S. A. Shevelev, *Mendeleev Commun*., 2004, 207.
5 A. M. Kuvshinov, V. I. Gulevskaya, V. V. Rozhkov and S. A. Shevelev, *Synthesis*, 2000, 1474.
6 A. M. Starosotnikov, A. V. Lobach, V. V. Kachala and S. A. Shevelev, *Izv. Akad. Nauk, Ser. Khim.*, 2004, 557 (*Russ. Chem. Bull., Int. Ed.*, 2004, **53**, 584).
7 D. M. Fink and J. T. Strupczewski, *Tetrahedron Lett*., 1993, 6525.
8 T. K. Shkineva, I. L. Dalinger, S. I. Molotov and S. A. Shevelev, *Tetrahedron Lett*., 2000, **41**, 4973.
9 S. G. Zlotin, P. G. Kislitsin, A. I. Podgursky, A. V. Samet and V. V. Semenov, *J. Org. Chem*., 2000, **65**, 8439.

Received: 20th January 2005; Com. 05/2451