Generation of oxodiazonium ions
2.* Synthesis of benzotetrazine-1,3-dioxides from 2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroanilines

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A new method for the synthesis of benzotetrazine-1,3-dioxides was developed, which involves the reaction of 2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroanilines with the Ac_2O/H_2SO_4 system. This method was also used for the synthesis of [1,2,5]oxadiazolo[3,4-*c*]cinnoline-5-oxide from 3-nitramino-4-phenylfurazan. The suggested mechanism of these reactions involves the formation of the intermediate oxodiazonium ion, resulting from acetylation of the oxygen atom of the nitramine group, followed by protonation and ionic dissociation. Then the oxodiazonium ion enters the intramolecular reaction with the neighboring *tert*-butyl-*NNO*-azoxy or phenyl group to form the corresponding heterocyclic systems.

Key words: 1,2,3,4-tetrazine-1,3-dioxides, cinnolines, azoxy compounds, nitramines, oxodiazonium cation, electrophilic aromatic substitution, ^1H, ^{13}C, and ^{14}N NMR spectroscopy.

We have previously developed the methods for synthesis of benzotetrazine-1,3-dioxides (BTDO) by the reaction of 2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroanilines with nitrating[2,3] (N_2O_5, NO_2BF_4) or phosphorylating[4] (P_4O_{10}, PCl_5) agents. In these reactions, the assumed mechanism of formation of 1,2,3,4-tetrazine-1,3-dioxide ring includes the formation of the oxodiazonium ion reacting with the adjacent azoxy group (Scheme 1). The oxodiazonium ion is formed by the reaction of the nitramine group with nitrating or phosphorylating agents.

A drawback of the synthesis of BTDO using nitrating agents is poor availability or high cost of the latter. When phosphorylating agents are used for the synthesis of BTDO, the yield of the desired product depends considerably on the substituents in the benzene ring.

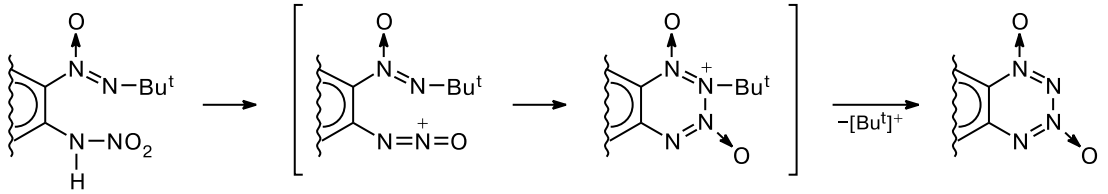
For cyclization of some 3-nitramino-4-(R-*NNO*-azoxy)furazans in [1,2,5]oxadiazolo[3,4-*e*][1,2,3,4]tetrazine-4,6-dioxide, the systems consisting of carboxylic acid anhydrides and strong mineral acids have recently[5] been used. The main purpose of this work is to study the possibility of using the Ac_2O/H_2SO_4 system for cyclization of 2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroanilines in BTDO. 2-(*tert*-Butyl-*NNO*-azoxy)-*N*-nitroaniline and its mono- and dibromosubstituted derivatives were chosen as model compounds.

Synthesis of the initial compounds. Nitration of 2-(*tert*-butyl-*NNO*-azoxy)anilines **1a—c** with nitronium tetrafluoroborate in MeCN as a solvent at −30 °C (Scheme 2) resulted in *N*-nitroamines **2a—c**.

Acetylation with acetyl chloride of the silver salt obtained from nitramine **2b** made it possible to synthesize *N*-nitro-*N*-acetyl compound **3b** in a moderate yield (Scheme 3). No product of *O*-acetylation of nitramine was observed.

The product obtained from compound **1a** was identical to the earlier described[4] nitramine **2a**. The structures

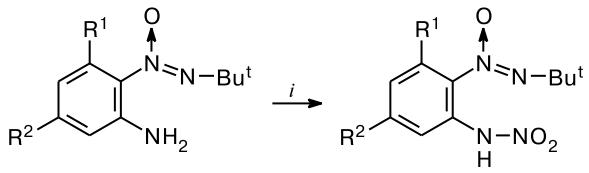
Scheme 1



* For Part 1, see Ref. 1.

Published in Russian in *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 10, pp. 2003—2008, October, 2011.

Scheme 2

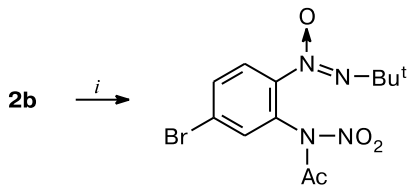


1a—c **2a—c**

i. NO_2BF_4, −30 °C.

$R^1 = R^2 = H$ (**a**), $R^1 = H$, $R^2 = Br$ (**b**), $R^1 = R^2 = Br$ (**c**)

Scheme 3



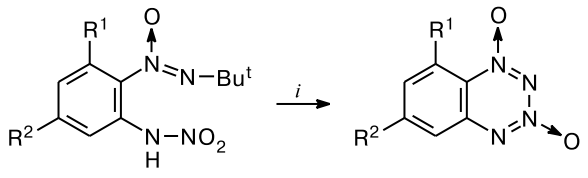
3b (39%)

i. 1) $AgNO_3$, $NH_3 \cdot H_2O$, 2) AcCl, Et_2O, −30→0 °C.

of nitramines **2b,c** and *N*-nitro-*N*-acetyl compound **3b** were confirmed by the ^1H, ^{13}C, and ^{14}N NMR spectra. In the ^{13}C NMR spectra of these compounds, the signals were completely assigned using the 2D ^1H—^{13}C NMR spectra (HMBC and HSQC).

Synthesis of BTDO 4a—c by the reaction of nitramines 2a—c with the Ac_2O/H_2SO_4 system. The reaction of 2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroanilines **2a—c** with Ac_2O starts only after the addition of H_2SO_4. As a result, BTDO **4a—c** are formed in good yields (Scheme 4, Table 1).

Scheme 4



2a—c **4a—c**

i. Ac_2O, H_2SO_4.

$R^1 = R^2 = H$ (**a**), $R^1 = H$, $R^2 = Br$ (**b**), $R^1 = R^2 = Br$ (**c**)

When catalytic amounts of 93% H_2SO_4 (10 mol.% with respect to nitramine) are used at 0 °C, the reaction rate is very low: the total conversion of the starting nitramine is attained within 2—10 days depending on the substrate. The temperature increase to 25 °C slightly accelerates the reaction (the reaction time was from 12 h to 2 days). An increase in the amount of H_2SO_4 to 1 equiv. allows nitramines **2a**,**b** to be transformed into the corresponding BTDO **4a**,**b** within 5 min at 0 °C in almost quantitative yields. At the same time, ring closure of nitramine **2c** requires 1 day under the same conditions and the yield of BTDO **4c** does not exceed 84%. An increase in the amount of sulfuric acid to 10 equiv. shortens the cyclization of nitramine **2c** to 5 min. A fairly low reaction rate of nitroaniline **2c** and the low yield of BTDO **4c** can be explained by the steric effect of the Br atom at the *ortho*-position to the *tert*-butyl-*NNO*-azoxy group.

The reactions using 1 equiv. of sulfuric acid are most suitable for preparative synthesis of BTDO **4a**,**b** (see Table 1, entries *3* and *6*). After hydrolysis of excess Ac_2O, the desired tetrazine-1,3-dioxides **4a**,**b** were isolated in quantitative yields by extraction with CH_2Cl_2. The conditions of entry *11* presented in Table 1 are optimum for synthesis of BTDO **4c**. Tetrazine-1,3-dioxide **4c** precipitates in an al-

Table 1. Synthesis of BTDO **4a—c** from nitramines **2a—c**

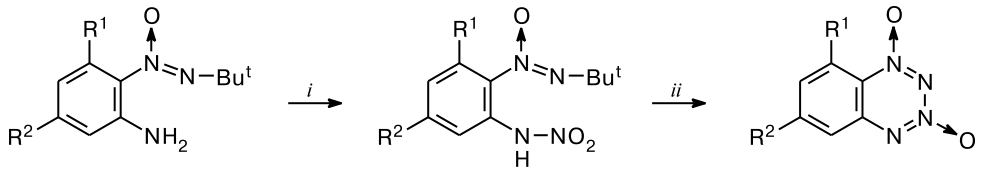
Entry	Nitramine **2**	Mole ratio **2** : H_2SO_4	T/°C[a]	Reaction time	BTDO	Yield of BTDO **4** (%)[b]
1	**2a**	1 : 0.1	25	12 h	**4a**	99
2	**2a**	1 : 0.1	0	2 days	**4a**	98
3	**2a**	1 : 1	0	5 min	**4a**	99
4	**2b**	1 : 0.1	25	2 days	**4b**	98
5	**2b**	1 : 0.1	0	7 days	**4b**	96
6	**2b**	1 : 1	0	5 min	**4b**	97
7	**2b**	1 : 10	25	2 min	**4b**	98
8	**2c**	1 : 0.1	0	10 days	**4c**	60
9	**2c**	1 : 0.1	25	2 days	**4c**	71
10	**2c**	1 : 1	0	1 day	**4c**	84
11	**2c**	1 : 10	0	5 min	**4c**	86[c]

[a] Reaction temperature.

[b] The yields of BTDO **4a—c** were determined from the ^1H NMR spectra. The conversion of compounds **2a—c** is complete.

[c] The yield of BTDO **4c** based on the isolated product. The conversion of compound **2c** is complete.

Scheme 5



1b,c **2b,c** **4b,c**

i. conc. HNO_3 (3—5 equiv.), Ac_2O, 0 °C, 5 min; *ii*. 93% H_2SO_4 (10 equiv.), 0 °C, 15 min.

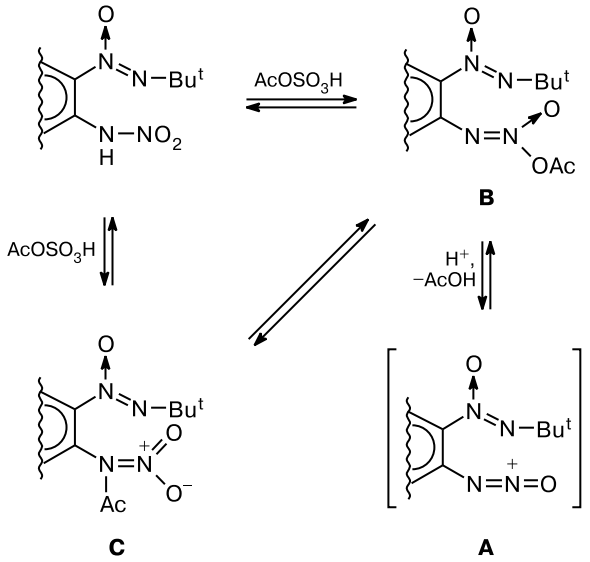
most pure form partially from the reaction mixture and partially after dilution of the reaction mixture with water.

Synthesis of BTDO **4b**,**c** was also carried out directly from 2-(*tert*-butyl-*NNO*-azoxy)anilines **1b**,**c** (Scheme 5, Table 2). For this purpose, an excess of concentrated HNO_3 was first added to a solution of aniline **1b**,**c** in acetic anhydride until the starting compound disappeared completely. This resulted in the formation of nitramines **2b**,**c** (TLC monitoring). Then an excess of H_2SO_4 was added to the reaction mixture. However, the yield of BTDO **4b**,**c** obtained by this procedure is substantially lower, which is due to the formation of a number of by-products impeding the isolation of BTDO.

Assumed scheme for the generation of the oxodiazonium ion from *N*-nitroamines under the action of the Ac_2O/H_2SO_4 system. It is assumed that the mechanism of formation of the 1,2,3,4-tetrazine-1,3-dioxide cycle in the above presented reactions, as well as in the reactions considered in the previous publications,[1—4] includes the step of formation of oxodiazonium ion **A**. The mechanism proposed for the formation of cation **A** from nitramines under the action of the Ac_2O/H_2SO_4 system is shown in Scheme 6. The reaction of Ac_2O with H_2SO_4 affords acetyl sulfate,[6] which acetylates nitramine at the oxygen atom with the formation of compound **B**. This compound is protonated by sulfuric acid and eliminates a molecule of AcOH yielding cation **A**, which further participates in the formation of the tetrazine-1,3-dioxide cycle (see Scheme 1).

Note that for topological reasons oxodiazonium cation **A**, leading to the tetrazine-1,3-dioxide cycle, can be formed directly only from *O*-acetylated compound **B**, but not from *N*-acetylated derivative **C**. Nevertheless, the alternative reaction scheme could include the formation of compound **C** and its transformation into compound **B** due to migration of the acetyl group from the nitrogen atom to the oxygen atom *via* the intra- or intermolecular mechanism. Additional studies were carried out to exclude the possibility of occurrence of the reaction *via* this scheme.

Scheme 6



C **A**

The conversion of *N*-nitro-*N*-acetyl compound **3b** to BTDO **4b** (Scheme 7) was studied under the same conditions (reactant ratio and concentrations) used for the transformation of nitramine **2b** into BTDO **4b** (see Scheme 4, Table 1, entry *7*). Compound **3b** completely disappears from the reaction mixture within 3 h at 25 °C (TLC data and the yield of BTDO **4b** is only 22% (data of ^{1}H NMR spectroscopy). Only trace amounts of BTDO **4b** and by-products are observed 5 min after the beginning of the reaction (TLC data). At the same time, the transformation of nitramine **2b** into BTDO **4b** was already completed in 2 min under the same conditions (see Scheme 4, Table 1, entry *7*), the yield of BTDO **4b** is 98% (data of ^{1}H NMR spectroscopy), and no even trace amounts of *N*-nitro-*N*-acetyl compound **3b** are observed in the reaction mixture (TLC data).

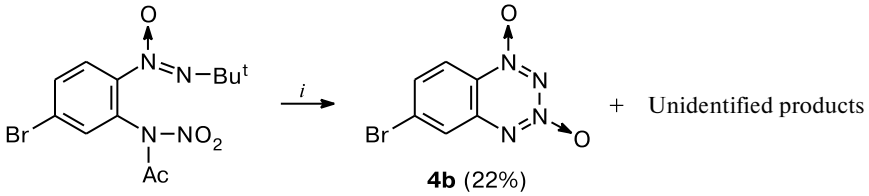
Table 2. Synthesis of BTDO **4b**,**c** from anilines **1b**,**c**[a]

Aniline	HNO_3 (экв.)	BTDO	Yield (%)[b]
1b	5	**4b**	73
1c	3	**4c**	60

[a] Reaction time was 5 min.

[b] The yields of BTDO **4b**,**c** based on the isolated product. The conversion of compounds **1b,c** is complete.

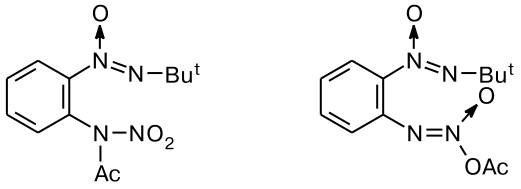
Схема 7



3b **4b** (22%)

i. Ac_2O, 93% H_2SO_4 (10 equiv.), 25 °C, 3 h.

Thus, it can be asserted that almost no *N*-nitro-*N*-acetyl compound **3b** is formed in the reaction of nitramine **2b** with the Ac_2O/H_2SO_4 system (see Scheme 4), *i.e.*, the reaction of the nitramine group with the Ac_2O/H_2SO_4 system includes mainly *O*- rather than *N*-acetylation, although *N*-acetylated nitramine is more stable than the *O*-acetylated analog according to the quantum chemical calculations. For example, the difference in enthalpies of formation between compounds **3a** and **5** is 6.8 kcal mol^{-1} (calculation using the Gaussian-98 program in the B3LYP/6-31G(d,p) basis set).



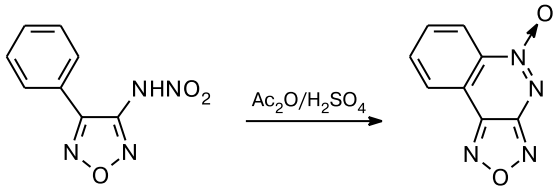
3a **5**

Reaction of 3-nitramino-4-phenylfurazan 6 with the Ac_2O/H_2SO_4 system. To confirm that the oxodiazonium ion is formed from nitramines under the action of acetyl sulfate, this cation was "captured" on the benzene ring in the intramolecular reaction of electrophilic aromatic substitution. These reactions of oxodiazonium cations generated from nitramines or their *O*-methyl derivatives were considered previously.[1]

The interaction of nitramine **6** with 2 equiv. of H_2SO_4 in Ac_2O results in furazano[3,4-*c*]cinnoline-5-oxide **7** (see Ref. 1) in 70% yield (Scheme 8). The reaction completes within several minutes as the reaction mixture is heated from 0 to 20 °C. The probable mechanism of generation of the oxodiazonium cation from nitramine **6** is described by Scheme 6.

Thus, we developed the new method for synthesis of benzotetrazine-1,3-dioxides (BTDO) from 2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroanilines under the action of the Ac_2O/H_2SO_4 system. The assumption about the transformation of the primary *N*-nitroamine group into the oxodiazonium fragment $[N{=}N{=}O]^+$ under the action of this system was confirmed by the conversion of 3-nitramino-4-phenylfurazan **6** to furazanocinnoline-5-oxide **7** using as an example.

Scheme 8



6 **7** (70%)

Experimental

^{1}H NMR spectra were recorded on Bruker AM-300 and Bruker DRX 500 instruments with frequencies of 300.13 and 500.13 MHz, respectively. ^{13}C and ^{14}N NMR spectra were measured on a Bruker DRX 500 instruments with frequencies of 125.76 and 36.14 MHz, respectively. Chemical shifts are presented relative to Me_4Si (^{1}H, ^{13}C) or $MeNO_2$ (^{14}N, external standard, the upfield chemical shifts are negative). IR spectra were recorded on a Specord M-80 spectrometer. Mass spectra were obtained on a Kratos MS-300 instrument (EI, 70 eV). Only peaks with isotopes ^{79}Br are given for the fragments containing bromine atoms. The reaction course and purity of the compounds were monitored by thin layer chromatography (Silufol UV-254 and Merck 60 F_{254}). Silica gel was used for preparative thin layer chromatography. 2-(*tert*-Butyl-*NNO*-azoxy)aniline,[7] 5-bromo-2-(*tert*-butyl-*NNO*-azoxy)aniline,[7] 3,5-dibromo-2-(*tert*-butyl-*NNO*-azoxy)aniline,[7] and 3-nitramino-4-phenyl-1,2,5-oxadiazole[1] were synthesized by known procedures. Distilled colorless HNO_3 (d = 1.5 g cm^{-1}) was used in the reactions.

3,5-Dibromo-2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroaniline (2c). This procedure is a modification of the earlier developed procedure.[4] To a suspension of aniline **1c** (0.3 g, 0.85 mmol) in anhydrous acetonitrile (8 mL), NO_2BF_4 (0.15 g, 1.12 mmol) was added by three portions for 15 min with vigorous stirring at −35 °C under argon. The reaction mixture was kept for 15 min at −35 °C, and then, without rising temperature, the reaction mixture was poured into a solution of $NaHCO_3$ (0.8 g) in water (20 mL). The aqueous layer was separated, washed with CH_2Cl_2 (3×7 mL), and acidified with a 10% aqueous solution of HCl to pH 2. The precipitate formed was filtered off, washed with H_2O (3×5 mL), and dried in a vacuum desiccator with P_2O_5. Nitramine **2c** was obtained as light yellow crystals in a yield of 211 mg (62%), m.p. 129—131 °C (decomp.). An additional amount of nitramine **2c**

was obtained by extraction of the combined aqueous filtrate with CH_2Cl_2 (5×5 mL). The organic extracts were combined, washed with brine (3 mL), dried ($MgSO_4$), and evaporated *in vacuo*. Additionally 56 mg (17%) of nitramine **2c** were obtained as light orange crystals. The overall yield was 79%. Found (%): C, 30.29; H, 3.08; N, 14.09. $C_{10}H_{12}Br_2N_4O_3$. Calculated (%): C, 30.44; H, 3.05; N, 13.82. IR (KBr), ν/cm^{-1}: 1244 w, 1308 s, 1360 w, 1460 w, 1488 s, 1560 w, 1596 s, 3260 s. ^{1}H NMR ($CDCl_3$), δ: 1.50 (s, 9 H, 3 Me); 7.79, 7.88 (both d, 1 H each, H(4), H(6), J = 2.0 Hz); 10.29 (br.s, 1 H, NH). ^{13}C NMR ($CDCl_3$), δ: 25.4 (Me); 61.8 (CMe_3); 116.5 (C(3)); 123.5 (C(5) or C(1)); 129.3 (C(6)); 129.7 (C(1) or C(5)); 135.5 (C(4)); 140.7 (br.s, C(2)). ^{14}N NMR ($CDCl_3$), δ: −38 (N—NO_2, $\Delta\nu_{1/2}$ = 60 Hz); −60 (N→O, $\Delta\nu_{1/2}$ = 130 Hz).

2-(*tert*-Butyl-*NNO*-azoxy)-*N*-nitroaniline (2a) was synthesized similarly in 50% yield, m.p. 91—92 °C (*cf.* Ref. 4: m.p. 91—92 °C) and is identical to the earlier obtained product[4] (^{1}H NMR spectrum).

5-Bromo-2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroaniline (2b) was synthesized similarly in 75% yield, m.p. 106—107 °C. Found (%): C, 37.82; H, 4.16; N, 17.61. $C_{10}H_{13}BrN_4O_3$. Calculated (%): C, 37.95; H, 4.12; N, 17.79. IR (KBr), ν/cm^{-1}: 1260 s, 1312 s, 1384 w, 1472 w, 1484 s, 1580 w, 1596 s, 3236 s. ^{1}H NMR ($CDCl_3$), δ: 1.50 (s, 9 H, 3 Me); 7.47 (dd, 1 H, H(4), J = 8.9 Hz, J = 1.8 Hz); 8.02 (d, 1 H, H(3), J = 8.9 Hz); 8.25 (d, 1 H, H(6), J = 1.8 Hz); 13.27 (br.s, 1 H, NH). ^{13}C NMR ($CDCl_3$), δ: 25.6 (Me); 60.6 (CMe_3); 125.7 (C(3)); 126.2 (C(5)); 126.9 (C(6)); 129.4 (C(4)); 130.7 (C(1)); 135.6 (br.s, C(2)). The signals were assigned by means of HMBC and HSQC experiments. ^{14}N NMR ($CDCl_3$), δ: −37 (N—NO_2, $\Delta\nu_{1/2}$ = 30 Hz); −53 (N→O, $\Delta\nu_{1/2}$ = = 90 Hz).

***N*-Acetyl-5-bromo-2-(*tert*-butyl-*NNO*-azoxy)-*N*-nitroaniline (3b).** A saturated aqueous solution of NH_3 (0.1 mL) was added to a suspension of nitramine **2b** (0.26 g, 0.82 mmol) in distilled water (3 mL), during this addition nitramine **2b** was dissolved completely. Then a solution of $AgNO_3$ (0.14 g, 0.82 mmol) in distilled water (0.5 mL) was added dropwise to the obtained solution. A white precipitate that formed was filtered off, washed with distilled water (3 mL) and EtOH (2 mL), and dried for 12 h in a vacuum desiccator over P_2O_5. The silver salt was obtained in a yield of 260 mg (75%) in the form of white crystals. The obtained salt was thoroughly milled in an agate mortar and used on the next step without additional purification. AcCl (0.02 mL, 0.28 mmol) was added as one portion to a suspension of the silver salt (0.12 g, 0.28 mmol) in anhydrous Et_2O (6 mL) at −30 °C under argon. The reaction mixture was stirred for 3 h at 0 °C and then kept for three days at the same temperature. The precipitate was filtered off and washed with Et_2O (2×4 mL). The filtrates were combined, and the solvent was evaporated *in vacuo*. The oily product was purified by preparative TLC (petroleum ether—AcOEt (20 : 1) mixture as eluent). *N*-Acetyl-*N*-nitroaniline **3b** was obtained in a yield of 40 mg (39%) as a yellow-orange oil. Found (%): C, 40.18; H, 4.19; N, 15.55. $C_{12}H_{15}BrN_4O_4$. Calculated (%): C, 40.03; H, 4.21; N, 15.80. ^{1}H NMR ($CDCl_3$), δ: 1.37 (s, 9 H, 3 Me); 2.68 (s, 3 H, Ac); 7.51 (d, 1 H, H(6), J = 2.1 Hz); 7.74 (dd, 1 H, H(4), J = 8.7 Hz, J = 2.1 Hz); 7.93 (d, 1 H, H(3), J = 8.7 Hz). ^{13}C NMR ($CDCl_3$) δ: 25.3 (CMe_3); 26.2 (C(O)Me); 60.1 (CMe_3); 124.7 (C(5)); 126.6 (C(3)); 128.9 (C(1)); 134.2 (C(6)); 134.6 (C(4)); 144.3 (br.s, C(2)); 168.6 (C(O)Me). The signals were assigned by means of HMBC and HSQC experiments. ^{14}N NMR ($CDCl_3$), δ: −43 (N—NO_2, $\Delta\nu_{1/2}$ = 35 Hz); −55 (N→O, $\Delta\nu_{1/2}$ = 70 Hz). MS, m/z: 313 $[M + H - NO_2]^+$.

Synthesis of BTDO 4a—c by the reaction of nitramines 2a—c with the Ac_2O/H_2SO_4 system (general procedure). A solution of 93% H_2SO_4 (the amount is given in Table 1) in Ac_2O (0.1 mL) was added in one portion to a solution of nitramine **2** (0.05 mmol) in Ac_2O (0.4 mL) with vigorous stirring under argon (the temperature is indicated in Table 1). Then the reaction mixture was kept at the same temperature for some time (see Table 1) and worked up. Method ***A*** was used for the spectral determination of the yield of BTDO **4a—c**. Water (2 mL) was added dropwise to the reaction mixture at 0 °C. The mixture was stirred for 1 h at 20 °C until hydrolysis of Ac_2O was completed and then extracted with CH_2Cl_2 (2×3 mL). The organic extracts were combined, washed with H_2O (2 mL) and brine (1 mL), dried ($MgSO_4$), and evaporated *in vacuo*. The yields of BTDO **4a—c** were determined by ^{1}H NMR spectroscopy after removal of the solvent. Method ***B*** was used for the isolation of BTDO **4c**. The yellow precipitate of BTDO **4c** was filtered off, washed with H_2O (0.5 mL), and dried in air. To obtain an additional amount of product **4c**, the filtrate was cooled to 0 °C, H_2O (2 mL) was added dropwise, and the mixture was stirred for 1 h at 20 °C. The precipitate was filtered off, washed with H_2O (1 mL), and dried in air. The yield of BTDO **4c** was determined from the overall yield of the precipitates. Purity of synthesized BTDO **4c** was monitored by ^{1}H NMR. The ^{1}H NMR spectra of compounds **4a—c** are identical to the spectra described.[3]

Synthesis of BTDO 4b,c from anilines 1b,c (general procedure). A solution of concentrated HNO_3 (for the amount of HNO_3, see Table 2) in Ac_2O (0.2 mL) was added on one portion at 0 °C with vigorous stirring under argon to a solution of aniline **1** (0.14 mmol) in Ac_2O (0.5 mL). The reaction mixture was stirred for 5 min at 0 °C, then a solution of 93% H_2SO_4 (0.076 mL, 1.4 mmol) in Ac_2O (0.2 mL) was added in one portion, and the mixture was stirred at 0 °C for 15 min more. To isolate BTDO **4b**, H_2O (8 mL) was added dropwise at 0 °C to the reaction mixture, and the mixture was stirred for 1 h at 20 °C. The mixture was cooled to 0 °C, and the yellow precipitate of BTDO **4b** was filtered off, washed with H_2O (2×1 mL), and dried in air. BTDO **4b** was obtained in a yield of 26 mg (73%). To isolate BTDO **4c**, the yellow precipitate was filtered off, washed with H_2O (2 mL), and dried in air. BTDO **4c** was obtained in a yield of 14 mg (30%). To obtain an additional amount of product **4c**, the filtrate was cooled to 0 °C, H_2O (2 mL) was added dropwise, the mixture was stirred for 1 h at 20 °C, and extracted with CH_2Cl_2 (2×4 mL). The organic extracts were combined, washed with H_2O (2 mL) and brine (1 mL), dried ($MgSO_4$), and evaporated *in vacuo*. Product **4c** was isolated by preparative TLC (petroleum ether—$CHCl_3$ (4 : 1, then 1 : 1) as eluent). Additional 14 mg (30%) of BTDO **4c** were obtained. The overall yield was 28 mg (60%).

Reaction of *N*-acetyl-*N*-nitroaniline 3b with the Ac_2O/H_2SO_4 system. A solution of 93% H_2SO_4 (0.015 mL, 0.28 mmol) in Ac_2O (0.1 mL) was added to a solution of *N*-acetyl-*N*-nitroaniline **3b** (10 mg, 0.028 mmol) in Ac_2O (0.4 mL) at 20 °C with vigorous stirring under argon. The reaction mixture was kept for 3 h at 20 °C and then cooled to 0 °C, H_2O (2 mL) was added dropwise, and the mixture was stirred for 1 h at 20 °C, and extracted with CH_2Cl_2 (3×2 mL). The organic extracts were combined, washed with brine (1 mL), dried ($MgSO_4$), and evaporated *in vacuo*. The yield of BTDO **4b** was determined by the ^{1}H NMR spectroscopy.

[1,2,5]-Oxadiazolo[3,4-*c*]cinnoline-5-oxide (7). A solution of 93% H_2SO_4 (0.017 mL, 0.3 mmol) in Ac_2O (0.1 mL) was added to a solution of 3-nitramino-4-phenyl-1,2,5-oxadiazole (**6**) (30 mg, 0.15 mmol) in Ac_2O (1.4 mL) at 0 °C with vigorous stirring. Cooling was removed, the reaction mixture was allowed to warm to 20 °C and poured into water (10 mL), and the mixture was stirred for 1 h to complete the hydrolysis of Ac_2O. The reaction mixture was extracted with CH_2Cl_2 (5×5 mL), the combined organic extracts were washed with a saturated aqueous solution of $NaHCO_3$ (2×10 mL) and brine (3 mL), dried ($MgSO_4$), and evaporated *in vacuo*. Cinnoline-5-oxide **7** was isolated by preparative TLC (petroleum ether—AcOEt (2 : 1) as eluent). Cinnoline-5-*N*-oxide **7** was obtained in a yield of 19 mg (70%), m.p. 167—169 °C (from CH_2Cl_2), and its physicochemical and spectral characteristics are identical to the earlier synthesized product.[1]

The authors are grateful to V. N. Solkan (N. D. Zelinsky Institute of Organic Chemistry, Russian Academy of Sciences) for help in quantum chemical calculations.

This work was financially supported by the Russian Foundation for Basic research (Project No. 10-03-00752).

References

1. M. S. Klenov, M. O. Ratnikov, A. M. Churakov, Yu. A. Strelenko, V. A. Tartakovsky, *Izv. Akad. Nauk*, *Ser. Khim.*, 2011, 523 [*Russ. Chem. Bull., Int. Ed.*, 2011, **60**, 536].
2. A. M. Churakov, S. L. Ioffe, V. A. Tartakovsky, *Mendeleev Commun.*, **1991**, 101.
3. A. M. Churakov, O. Yu. Smirnov, S. L. Ioffe, Yu. A. Strelenko, V. A. Tartakovsky, *Eur. J. Org. Chem.*, 2002, 2342.
4. A. E. Frumkin, A. M. Churakov, Yu. A. Strelenko, V. A. Tartakovsky, *Izv. Akad. Nauk*, *Ser. Khim.*, 2000, 480 [*Russ. Chem. Bull.*, *Int. Ed.*, 2000, **49**, 482].
5. V. P. Zelenov, A. A. Lobanova, S. V. Sysolyatin, *Mater. dokl. Mezhdunar. nauchno-tekhn. i metodich. konf. "Sovremennye problemy tekhnicheskoi khimii"* [*Proceedings of the International Scientific Technical and Methodical Conference "Modern Problems of Technical Chemistry"*] *(Kazan, December 22—24, 2004)*, Kazan, 2004, 337 (in Russian).
6. O. Stillich, *Chem. Ber.*, 1905, **38**, 1245.
7. A. M. Churakov, O. Yu. Smirnov, S. L. Ioffe, Yu. A. Strelenko, V. A. Tartakovsky, *Izv. Akad. Nauk*, *Ser. Khim.*, 1994, 1620 [*Russ. Chem. Bull.* (*Engl. Transl.*), 1994, **43**, 1532].

Received February 8, 2011;
in revised form March 25, 2011