Nitropyrazoles

17.* Synthesis of 1-(3,5-dinitrophenyl)-4-methyl-3,5-dinitropyrazole and the study of its chemical transformations

A. A. Zaitsev,[a] D. V. Zaiko,[b] I. L. Dalinger,[a] V. V. Kachala,[a] T. K. Shkineva,[a] and S. A. Shevelev[a]★

[a]*N. D. Zelinsky Institute of Organic Chemistry, Russian Academy of Sciences, 47 Leninsky prosp., 119991 Moscow, Russian Federation. Fax: +7 (499) 135 5328. E-mail: shevelev@ioc.ac.ru*
[b]*D. I. Mendeleev University of Chemical Technology of Russia, 9 Miusskaya pl., 125047 Moscow, Russian Federation*

A new one-step method for the synthesis of 4-methyl-3(5)-nitropyrazole by nitration of 4-methylpyrazole is developed. Arylation of 4-methyl-3(5)-nitropyrazole with 1,3,5-trinitrobenzene gives 1-(3,5-dinitrophenyl)-4-methyl-3-nitropyrazole, nitration of which leads to 1-(3,5-dinitrophenyl)-4-methyl-3,5-dinitropyrazole. The action of 1 equiv. of an O- or S-nucleophile (phenolate, *p*-chlorobenzenethiolate and ethoxide ions; anions of glycolanilide and thioglycolanilide) on 1-(3,5-dinitrophenyl)-4-methyl-3,5-dinitropyrazole led to the substitution of the 5-NO_2 group of the pyrazole ring; under the action of one more equivalent of a nucleophile the NO_2 group of the benzene ring was substituted. The substitution product of the anion of thioglycolanilide for the 5-NO_2 group undergoes the intramolecular cyclization — oxidative nucleophilic hydrogen substitution in the benzene ring under the action of K_2CO_3.

Key words: nitropyrazoles, dinitropyrazoles, 1,3,5-trinitrobenzene, nitration, nucleophilic substitution, nucleophiles, enamines, protecting groups, the Smiles rearrangement.

In our previous work,[2] we have demonstrated that the introduction of the 2,4-dinitrophenyl substituent in the position 1 of the pyrazole ring increases the mobility of hydrogen atoms of the 4-Me group in comparison with the corresponding 1-Me analog. So, 1-(2,4-dinitrophenyl)-4-methyl-3,5-dinitropyrazole (**1**) undergoes condensation reaction with dimethylformamide dimethylacetal (DMF DMA) and aromatic aldehydes under much milder conditions than 1,4-dimethyl-3,5-dinitropyrazole. This fact can be used for the functionalization of the pyrazole ring at the position 4. At the same time, the sensitivity of the position 1 of the benzene ring in compound **1** is very high, it considerably exceeds the sensitivity of the position 5 of the pyrazole ring. The substitution at C(1) atom of the 2,4-dinitrophenyl fragment occurs under the action of anionic nucleophilic reagents Nu^- so that 1-R-2,4-dinitrobenzenes and 4-methyl-3,5-dinitropyrazole (**2**) are formed. The introduction of an electron-withdrawing substituent that is resistant to the action of a nucleophile in the position 1 of the pyrazole ring would enable carrying out nucleophilic substitution in the position 5 of the pyrazole ring, and hence, functionalization of the position 5 of the pyrazole ring. Moreover, the electron-withdrawing substituent in the position 1 should enhance the reactivity of the position 5 in reactions with nucleophilic reagents. We assumed that 3,5-dinitrophenyl group can be such a substituent, as, from one hand, the presence of two nitro groups would provide electron-withdrawing effect similar to that of the isomeric 2,4-dinitrophenyl substituent, and, from the other hand, the nitro groups are located in such a way that the position 1 of the benzene ring is not activated with respect to nucleophilic substitution.

We considered three possible approaches to the synthesis of 1-(3,5-dinitrophenyl)-4-methyl-3,5-dinitropyrazole (**3**) (Scheme 1): (*a*) arylation of 4-methylpyrazole (**4**) with trinitrobenzene (TNB) followed by nitration of product **5**; (*b*) nitration of methylpyrazole **4** to dinitro derivative[1] **2** and arylation of the latter with TNB; (*c*) nitration of methylpyrazole **4** to mononitro derivative **6**, its arylation with TNB followed by nitration of product **7**.

Methylpyrazole **4** does not react with TNB in the presence of K_2CO_3 in refluxing acetonitrile (80 °C), or in DMF at 100 °C for 20—30 h. This is in accord with the data from publication[3] in which it was noted that NH-pyrazoles having high pK_a values either do not undergo arylation with TNB (3,5-dimethylpyrazole), or are arylated over long period in low yields (pyrazole).

The attempts of arylation of nitropyrazole **2**, which was obtained by nitration of methylpyrazole **4** using the method that we have developed earlier,[1] were also unsuc-

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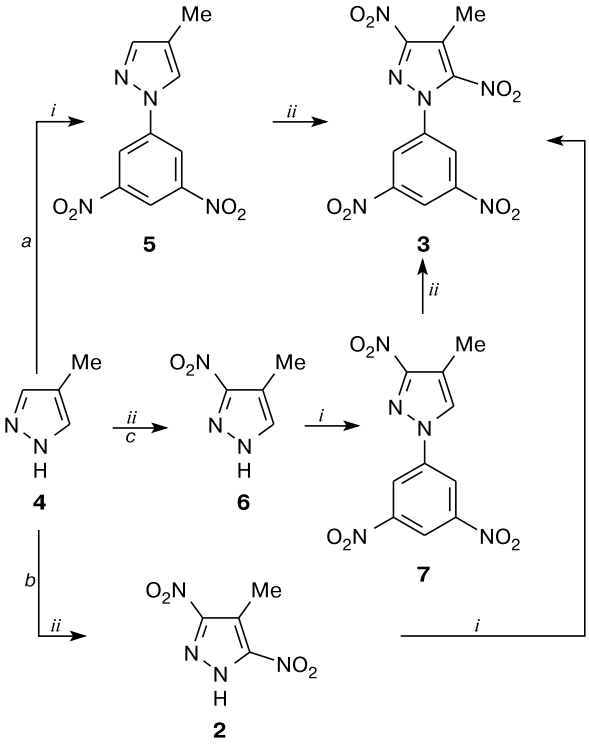
Scheme 1



i. Arylation; *ii*. Nitration.

cessful. Trinitrobenzene does not react with nitropyrazole **2** in refluxing acetonitrile in the presence of K_2CO_3, resinification of the reaction mixture occurs when the reaction is carried out at 100 °C in DMF. This result, apparently, is caused by low nucleophilicity of 4-methyl-3,5-dinitropyrazolate anion.

We developed direct one-step method for the synthesis of 4-methyl-3(5)-nitropyrazole (**6**) from methylpyrazole **4** in order to realize the approach (*c*) for the synthesis of nitropyrazole **3.***

In order to find the optimum conditions for the one-step synthesis of compound **6**, we carried out a series of experiments on nitration of methylpyrazole **4** with nitric acid — sulfuric acid mixture at 100 °C for 2 h, where the concentration of sulfuric acid and the nitric acid : methylpyrazole **4** ratio were varied (Scheme 2, Table 1).

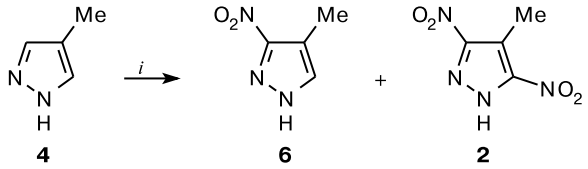
* The known method for synthesis of compound **6** from **4** comprises two steps: *N*-nitration of 4-methylpyrazole **4** with acetyl nitrate and subsequent thermal rearrangement of 4-methyl-1-nitropyrazole that formed.[4] Total yield of nitropyrazole **6** in this method is 36%, but it should be taken into account that the claimed yield of 62% for the rearrangement step is accessible only when preliminarily purified *N*-nitropyrazole is used. At the same time, the yield of unpurified 4-methyl-1-nitropyrazole is 61%,[4] *i.e.*, the real yield of 4-methyl-3(5)-nitropyrazole **6** is smaller than 36%.

Table 1. Conditions of nitration of 4-methylpyrazole (**4**) and yields of the reaction products

Run	$[H_2SO_4]$ (%)	HNO_3 : **4** (mol.)	Yield (%)*	
			6	**2**
1	92.5	2.0	6	0
2	94.5	1.5	20	3
3	95.0	1.5	25	5
4	95.5	1.5	36	10
5	96.5	1.5	52	14
6	96.5	1.25	57	6
7	97.5	1.5	46	29
8	97.5	1.25	50	22
9	97.5	1.05	39	12
10	97.5	3.0	0	75

* Yields of reaction products in mixtures of compounds **6** + **2** are given; the yields were determined using masses of the obtained mixtures and the ratio **6** : **2** in the ^{1}H NMR spectra.

Scheme 2



i. HNO_3 (d = 1.5 g cm^{-3}), H_2SO_4, 100 °C, 2 h.

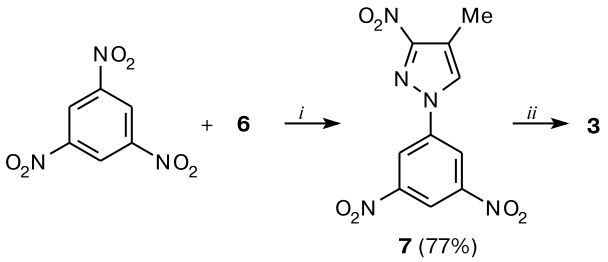
The results of the experiments show that the yields of nitropyrazoles **6** and **2** increase with the increase in the sulfuric acid concentration, and the maximum yield of mononitro derivative **6** is observed at $[H_2SO_4]$ = 96.5%; the conditions of run *6* (see Table 1) are optimal for the synthesis of nitropyrazole **6**, the yield of pure nitropyrazole **6** was 47% (after removal of admixture **2**).

It is worth noting that the formation of dinitro derivative **2** occurs at any concentration of H_2SO_4 starting from 94.5%, and at any HNO_3 : **4** ratio (the most representative are the results of the run *9* where the use of 5% excess of nitric acid as regards mononitration led to compound **2** in 12% yield). This implies that the rate of nitration of nitropyrazole **6** is higher than that of methylpyrazole **4**. The possible explanation of this fact is as follows: according to the literature data,[5] pyrazoles that are substituted in the position 4 undergo nitration in the form of free bases and the observed difference in nitration rates is due to differences in concentration of the free bases of **4** and **6** in the reaction medium — methylpyrazole **4** (pK_{BH^+} = 3.04)[6] is totally in the form of the conjugated acid in concentrated sulfuric acid, while nitropyrazole **6**, whose pK_{BH^+} value is seven orders of magnitude lower than that of **4** (for 3(5)-nitropyrazole pK_{BH^+} = –4.66)[6], is predominately in

the form of a free base. Thus, on the basis of the aforesaid, the existence of the maximum of yield of compound **6** at the concentration of H_2SO_4 of 96.5% becomes understandable. Simultaneous formation of mono- and dinitro products as the incomplete conversion of the starting pyrazole has earlier been described.[7]

The reaction of nitropyrazole **6** with TNB in the presence of K_2CO_3 led to the single arylation product **7** (Scheme 3). The position of the nitro group in the pyrazole ring in compound **7** was determined in the following way. The signals for the C atoms of the CH- and CNO_2 groups in the ^{13}C NMR of compound **7** are at δ 132.24 and 155.17, respectively (the assignment was made using 2D correlation spectroscopy on the basis of long-range (HMBC) and direct (HSQC) spin-coupling constants $^1H—^{13}C$), the difference magnitude $|\delta(C(3)) - \delta(C(5))|$ was 22.93 ppm. Analysis of data[8] of the ^{13}C NMR spectra of 3-NO_2-5-H- and 5-NO_2-3-H-pyrazoles, which contain hydrogen or an aliphatic carbon atom in the position 4, demonstrates that chemical shifts for the C(3) and C(5) atoms of 3-nitropyrazoles are at δ 148.9—160.1 and δ 124.4—137.1, respectively, and the difference magnitude $|\delta(C(3)) - \delta(C(5))|$ is 20.0—27.9 ppm; the chemical shifts for C(3) and C(5) atoms of 5-nitropyrazoles are at δ 133.6—139.6 and δ 142.3—146.6, and the difference magnitude $|\delta(C(3)) - \delta(C(5))|$ is in the range 6.4—8.7 ppm. Thus, the comparison of values of chemical shifts for C(3) and C(5) atoms in the ^{13}C NMR spectrum of compound **7** with the literature data shows unambiguously that the NO_2 group is in the position 3 of the pyrazole ring.

Scheme 3



i. K_2CO_3/MeCN, 80 °C, 4 h; *ii*. HNO_3 ($d = 1.5$ g cm^{-3}), H_2SO_4, 100 °C, 2 h.

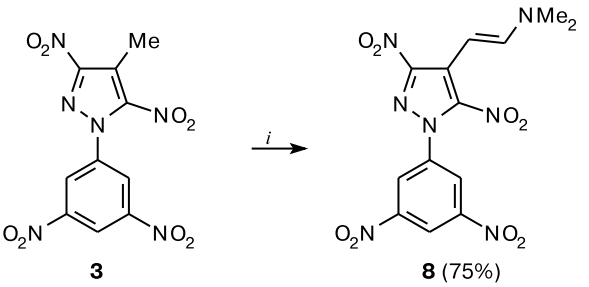
Table 2. Conditions of nitration of 1-(3,5-dinitrophenyl)-4-methyl-3-nitropyrazole (**7**) and yields of 1-(3,5-dinitrophenyl)-4-methyl-3,5-dinitropyrazole (**3**)

Run	$[H_2SO_4]$ (%)	HNO_3 : **7** (mol.)	Yield of **3** (%)
1	96.5	5	46
2	96.5	2	79
3	98.5	5	74

Nitropyrazole **3** is formed upon nitration of arylation product **7** with a sulfuric—nitric acid mixture (see Scheme 3). The optimum conditions for the nitration of compound **7** are those of run *2* (see Table 2).

We investigated the behavior of nitropyrazole **3** in the condensation reaction with DMF DMA. It turned out that enamine **8** is formed in refluxing toluene for 10 h (Scheme 4). The mobility of hydrogen atoms of 4-Me group of compound **3** in this reaction is very close to that of nitropyrazole **1**, which reacts with DMF DMA under similar conditions,[2] and is much higher than the mobility of hydrogen atoms of the 4-Me group in 1,4-dimethyl-3,5-dinitropyrazole, which reacts with DMF DMA only in refluxing DMF.[9] Thus, the electron-withdrawing effect of the isomeric 2,4-dinitro- and 3,5-dinitrophenyl groups is approximately the same.

Scheme 4



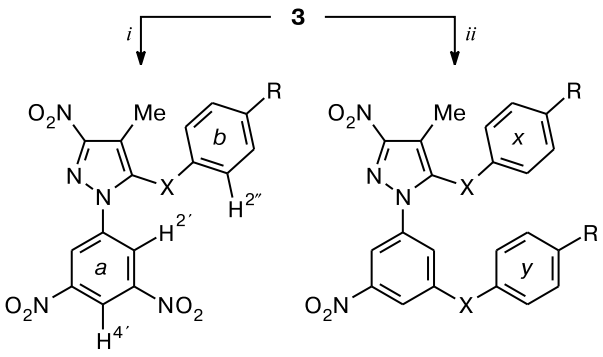
i. $Me_2NCH(OMe)_2$, $PhCH_3$, reflux, 10 h.

We investigated the substitution reactions of nitropyrazole **3** with different S- and O-nucleophiles. Theoretically, one can expect that under the action of nucleophilic reagents compound **3** would react along one of the following routes: (*a*) substitution of one or several NO_2 group in the position 5 of the pyrazole ring; (*b*) substitution of the NO_2 group in the position 3 of the pyrazole ring; (*c*) substitution of the NO_2 group in the position 3 of the benzene ring; (*d*) substitution of the 4-methyl-3,5-dinitropyrazolate anion in the position 1 of the benzene ring; (*e*) the formation of anionic σ-complexes under nucleophile attack on the positions 2 or 4 of the benzene ring and their further transformations.

The reaction of nitropyrazole **3** with equimolar amounts of phenolate or *p*-chlorobenzenethiolate anions results in single products **9a** and **9b**, respectively (Scheme 5). The fact that it is the NO_2 group of the pyrazole ring of compound **3** that is substituted followed from the ^1H NMR spectra of compounds **9a** and **9b** where only two signals for the protons of the benzene ring (*a*) are observed in the ratio 2 : 1. The use of the 2D correlation spectroscopy ROESY for compound **9a** and NOESY for **9b** shows the existence of the interaction between H(2′) and H(2″) protons, which is possible only in the case where the phenoxyl

(*p*-chlorophenylsulfanyl) substituent is in the position 5 of the pyrazole ring.

Scheme 5



	X	R	Yield (%)
9a	O	H	83
9b	S	Cl	70
10a	O	H	62
10b	S	Cl	48

i. *p*-RC_6H_4XH (1 equiv.), K_2CO_3, MeCN, 80 °C; *ii*. *p*-RC_6H_4XH (2 equiv.), K_2CO_3, MeCN, 80 °C.

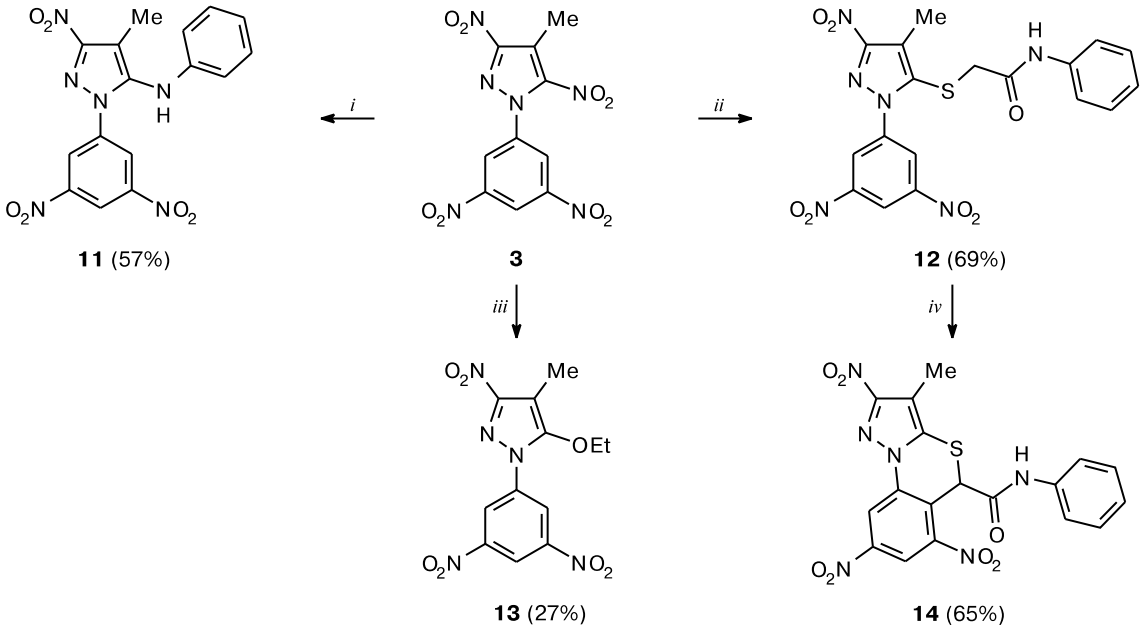
The action of 2 equiv. of phenolate or *p*-chlorobenzenethiolate ions on compound **3** leads to the substitution of both of the NO_2 group of the pyrazole ring, and the NO_2 group of the benzene ring to give compounds **10a** and **10b**, respectively (see Scheme 5).

Similarly, the action of the thioglycolanilide or glycolanilide anions on nitropyrazole **3** leads to the substitution products of the 5-NO_2 group of the pyrazole ring, whereby not the corresponding amide but 5-anilino-1-(3,5-dinitrophenyl)-4-methyl-3-nitropyrazole (**11**), the product of the Smiles rearrangement of the intermediate oxygen-containing anilide, analogous to sulfur-containing compound **12**, is formed (Scheme 6). We have demonstrated the occurrence of the Smiles rearrangement in the nitropyrazole series in our previous work.[10] It is worth noting that nucleophilic substitution the ethoxide anion for the 5-NO_2 group in compound **3** occurs on simple reflux in ethanol in the presence of K_2CO_3 (compound **13** is formed, see Scheme 6).

The action of K_2CO_3 on compound **12** in MeCN leads to intramolecular oxidative substitution of hydrogen atom in the position 2 of the dinitrophenyl fragment, which gives compound **14**, a representative of the earlier unknown tricyclic system 5*H*-pyrazolo[1,5-*a*][3,1]benzothiazine (see Scheme 6). The question of the oxidation reagent in this reaction needs special investigation. For example, both the starting compound **12** and atmospheric oxygen can serve as the oxidating reagent.

The position of the nitro group at the C(3) atom of the pyrazole ring in compound **11** was determined in the following way. In the 2D correlation spectrum HMBC $^1H—^{15}N$, the only interaction of the hydrogen

Scheme 6



i. $HOCH_2CONHPh$, K_2CO_3, MeCN, 80 °C, 4 h; *ii*. $HSCH_2CONHPh$, K_2CO_3, MeCN, 25 °C, 20 h; *iii*. K_2CO_3/EtOH, ~80 °C, 6 h; *iv*. K_2CO_3/MeCN, 25 °C, 48 h.

atom of the NH group with the nitrogen atom N(1) of the pyrazole ring is observed (δ −175.3), which is possible only in the case where the NHPh substituent is linked to the C(5) atom of the pyrazole ring. The formation of compound **14** from **12** is the chemical proof of the location of the $SCH_2CONHPh$ group in the position 5 of the pyrazole ring.

Thus, the introduction of the 3,5-dinitrophenyl substituent in the position 1 of the pyrazole ring, first, increases the reactivity of the 4-Me group with respect to DMF DMA in comparison with the 1-methyl analog and, second, increases the reactivity of the position 5 of the pyrazole ring with respect to nucleophilic reagents. Thus, dinitropyrazole **3**, unlike 1,4-dimethyl-3,5-dinitropyrazole, reacts with S-, as well as with O-nucleophiles, which extends the potential of functionalization of the pyrazole ring at the position 5.

Experimental

^1H and ^{13}C NMR spectra were recorded on Bruker AC-300 (300.13 MHz) and Bruker DRX-500 (125 MHz) spectrometers at 295 K (unless other temperature is indicated). Chemical shifts for ^1H and ^{13}C are given relative to Me_4Si. IR spectra were recorded on a Specord M-80 instrument in KBr pellets. Mass spectra were obtained on a Kratos MS-30 spectrometer (direct inlet, electron impact, ionization energy 70 eV). The course of the reactions and the control of purity of the compounds were carried out by TLC on Silufol UV-254 plates in $CHCl_3$—Me_2CO (10 : 1). Elemental analysis was carried out on a Perkin—Elmer Series II 2400 apparatus.

4-Methylpyrazole,[11] thioglycolanilide,[12] and glycolanilide[13] were synthesized by the previously described methods.

4-Methyl-3(5)-nitropyrazole (6). Oleum (41%, d = 1.963 g cm^{-3}, 230 mL) was added to sulfuric acid (d = 1.826 g cm^{-3}, 780 mL) keeping the temperature at 30—40 °C, then methylpyrazole **4** (52.0 mL, 0.629 mol) was added portionwise to the solution at 30—40 °C, and then fuming nitric acid (d = 1.5 g cm^{-3}, 33.0 mL, 0.786 mol) was added dropwise. The reaction mixture was heated at 100—105 °C for 2 h, cooled to ~20 °C, poured onto crushed ice (~3 kg); air was bubbled for 3—4 h through the suspension obtained until total removal of nitrogen oxides. The solution was extracted with ethyl acetate (3×500 mL), the combined extracts were washed with brine to neutral pH and with 5% solution of NaOAc until all nitropyrazole **2** was removed (TLC) and dried over Na_2SO_4. The solvent was removed under reduced pressure, the residue was recrystallized from water. Colorless crystals of compound **6** were obtained (37.6 g, 47%). M.p. 187—188 °C (lit. data[4]: m.p. 187 °C). ^1H NMR ($(CD_3)_2SO$), δ: 13.62 (s, 1 H, NH); 7.82 (s, 1 H, CH); 2.26 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 153.97 (C(3)); 131.44 (C(5)); 112.85 (C(4)); 9.43 (Me). IR, ν/cm^{-1}: 3152, 3132, 2940 (NH); 1528, 1376, 1344 (NO_2). MS, m/z: 127 [M]$^+$.

1-(3,5-Dinitrophenyl)-4-methyl-3-nitropyrazole (7). K_2CO_3 (0.397 g, 2.9 mmol) was added to a solution of nitropyrazole **6** (0.429 g, 3.4 mmol) and TNB (0.720 g, 3.4 mmol) in acetonitrile (45 mL). The reaction mixture was refluxed for 4 h (TLC), then cooled and poured into water (250 mL), acidified with HCl to pH 2—3; the precipitate that formed was filtered off, washed with water, and dried in air. Orange-brown solid compound **7** was obtained (0.765 g, 77%). M.p. 172—174 °C. Found (%): C, 40.91; H, 2.49; N, 23.54. $C_{10}H_7N_5O_6$. Calculated (%): C, 40.97; H, 2.41; N, 23.89. ^1H NMR ($(CD_3)_2SO$), δ: 9.07 (s, 1 H, H(5)); 9.04 (d, 2 H, H(2′), J = 2.1 Hz); 8.84 (t, 1 H, H(4′), J = 2.1 Hz); 2.37 (s, 3 H, Me). ^1H NMR ($CDCl_3$), δ: 9.05 (s, 1 H, H(5)); 8.95 (s, 2 H, H(2′)); 8.06 (s, 1 H, H(4′)); 2.49 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 155.17 (C(3)); 148.87 (C(3′)); 139.49 (C(1′)); 132.24 (C(5)); 118.98 (C(2′)); 117.10 (C(4′)); 116.53 (C(4)); 9.45 (Me). IR, ν/cm^{-1}: 1548, 1520, 1344 (NO_2). MS, m/z: 293 [M]$^+$.

1-(3,5-Dinitrophenyl)-4-methyl-3,5-dinitropyrazole (3). Oleum (41%, d = 1.963 g cm^{-3}, 2.2 mL) was added to sulfuric acid (92.5%, d = 1.826 g cm^{-3}, 7.5 mL) keeping the temperature at 30—40 °C, then nitropyrazole **7** (1.00 g, 3.4 mmol) was added portionwise to the solution at 30—40 °C, and then fuming nitric acid (d = 1.5 g cm^{-3}, 0.3 mL, 7.1 mmol) was added dropwise. The reaction mixture was heated at 100—105 °C for 2 h, cooled to ~20 °C, poured onto crushed ice (~70 g); air was bubbled for 2 h through the suspension obtained until total removal of nitrogen oxides. The precipitate that formed was filtered off, washed with water to neutral pH, dried in air and recrystallized from MeCN-EtOH mixture (1 : 1). Light-beige compound **3** was obtained (0.916 g, 79%). M.p. 220—222 °C. Found (%): C, 35.40; H, 1.88; N, 24.59. $C_{10}H_6N_6O_8$. Calculated (%): C, 35.51; H, 1.79; N, 24.85. ^1H NMR ($(CD_3)_2SO$), δ: 9.11 (d, 2 H, H(2′), J = 1.8 Hz); 9.03 (t, 1 H, H(4′), J = 1.8 Hz); 2.70 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 153.06 (C(3)); 148.10 (C(3′)); 144.39 (C(5)); 139.69 (C(1′)); 127.67 (C(2′)); 120.42 (C(4′)); 115.21 (C(4)); 9.78 (Me). IR, ν/cm^{-1}: 1560, 1544, 1540, 1532, 1348, 1332 (NO_2). MS, m/z: 338 [M]$^+$.

(*E*)-*N*,*N*-Dimethyl-2-[1-(3,5-dinitrophenyl)-3,5-dinitropyrazol-4-yl]vinylamine (8). Dimethylformamide dimethylacetal (1.0 mL, 7.5 mmol) was added to a mixture of toluene (20 mL) and dinitropyrazole **3** (1.00 g, 3.5 mmol), the reaction mixture was refluxed for 10 h (TLC). The reaction mixture was cooled to ~20 °C, toluene was removed under reduced pressure. The residue was recrystallized from ethanol, dark-purple solid compound **8** was obtained (0.87 g, 75%). M.p. 186—187 °C (decomp.). Found (%): C, 39.43; H, 2.53; N, 24.75. $C_{13}H_{11}N_7O_8$. Calculated (%): C, 39.70; H, 2.82; N, 24.93. ^1H NMR ($(CD_3)_2SO$), δ: 9.03 (s, 2 H, H(2′)); 8.97 (s, 1 H, H(4′)); 8.14 (d, 1 H, CH=C<u>H</u>NMe$_2$, J = 12.4 Hz); 5.77 (d, 1 H, C<u>H</u>=CHNMe$_2$, J = 12.4 Hz); 3.08 (br.s, 6 H, 2 Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 153.47 (CH=<u>C</u>HNMe$_2$); 150.40 (C(3)); 147.89 (C(3′)); 140.67 (C(1′)); 139.31 (C(5)); 126.49 (C(2′)); 121.87 (C(4)); 119.26 (C(4′)); 79.99 (<u>C</u>H=CHNMe$_2$); the broad peak of the C atoms of the Me groups is hidden under the solvent peak in the region δ 40.5—38.5. IR, ν/cm^{-1}: 1540, 1380, 1364, 1352, 1336 (NO_2). MS, m/z: 393 [M]$^+$.

1-(3,5-Dinitrophenyl)-4-methyl-3-nitro-5-phenoxypyrazole (9a). K_2CO_3 (0.220 g, 1.6 mmol) was added to a solution of dinitropyrazole **3** (0.502 g, 1.5 mmol) and phenol (0.150 g, 1.6 mmol) in acetonitrile (30 mL), the reaction mixture was refluxed for 1—1.5 h (TLC). The reaction mixture was cooled to ~20 °C, poured into water (120 mL), acidified with HCl to pH 2—3, extracted with ethyl acetate (2×40 mL); the organic layers were combined, washed with water to neutral pH, dried over Na_2SO_4, the solvent was removed under reduced pressure. The residue was chromatographed on silica gel ($CHCl_3$). Light-

yellow solid compound **9a** was obtained (0.477 g, 83%). M.p. 108—110 °C. Found (%): C, 49.81; H, 2.66; N, 18.41. $C_{16}H_{11}N_5O_7$. Calculated (%): C, 49.88; H, 2.88; N, 18.18. ^{1}H NMR ($(CD_3)_2SO$), δ: 8.87 (s, 2 H, H(2′)); 8.84 (s, 1 H, H(4′)); 7.41 (t, 2 H, *o*-H, Ph, *J* = 7.7 Hz); 7.21 (m, 3 H, *m*-H, Ph + *p*-H, Ph); 2.08 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 155.06 (*ipso*-C, Ph); 153.62 (C(3)); 148.48 (C(3′)); 147.27 (C(5)); 137.44 (C(1′)); 130.48 (*m*-C, Ph); 124.85 (*p*-C, Ph); 122.60 (C(2′)); 118.15 (C(4′)); 115.75 (*o*-C, Ph); 103.28 (C(4)); 7.77 (Me). IR, ν/cm^{-1}: 1548, 1344 (NO_2). MS, *m/z*: 385 $[M]^+$.

5-(4-Chlorophenylsulfanyl)-1-(3,5-dinitrophenyl)-4-methyl-3-nitropyrazole (9b). K_2CO_3 (0.225 g, 1.6 mmol) was added to a solution of dinitropyrazole **3** (0.500 g, 1.5 mmol) and *p*-chlorobenzenethiol (0.214 g, 1.5 mmol) in acetonitrile (30 mL), the reaction mixture was refluxed in a flow of argon for 30 min (TLC). The reaction mixture was cooled to ~20 °C, poured into water (120 mL), acidified with HCl to pH 2—3; the precipitate that formed was filtered off, washed with water, and chromatographed on silica gel ($CHCl_3$). Light-yellow solid compound **9b** was obtained (0.450 g, 70%). M.p. 176—179 °C. Found (%): C, 43.86; H, 2.23; N, 15.83; S, 7.62. $C_{16}H_{10}ClN_5O_6S$. Calculated (%): C, 44.10; H, 2.31; N, 16.07; S, 7.36. ^{1}H NMR ($(CD_3)_2SO$), δ: 8.94 (s, 1 H, H(4′)); 8.89 (s, 2 H, H(2′)); 7.33 (d, 2 H, *m*-H, C_6H_4Cl-*p*, *J* = 8.8 Hz); 7.15 (d, 2 H, *o*-H, C_6H_4Cl-*p*, *J* = 8.8 Hz); 2.41 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 154.72 (C(3)); 148.06 (C(3′)); 138.59 (C(1′)); 134.53 (C(5)); 132.18 (*p*-C, C_6H_4Cl-*p*); 131.58 (*ipso*-C, C_6H_4Cl-*p*); 129.63 (*m*-C, C_6H_4Cl-*p*); 129.25 (*o*-C, C_6H_4Cl-*p*); 126.36 (C(2′)); 121.86 (C(4)); 119.43 (C(4′)); 10.09 (Me). IR, ν/cm^{-1}: 1548, 1344 (NO_2). MS, *m/z*: 437, 435 (1 : 3) $[M]^+$.

4-Methyl-3-nitro-1-(3-nitro-5-phenoxyphenyl)-5-phenoxypyrazole (10a). K_2CO_3 (0.460 g, 3.3 mmol) was added to a solution of dinitropyrazole **3** (0.505 g, 1.5 mmol) and phenol (0.303 g, 3.2 mmol) in acetonitrile (30 mL), the reaction mixture was refluxed for 8—10 h (TLC). The reaction mixture was cooled to ~20 °C, poured into water (120 mL), acidified with HCl to pH 2—3, extracted with ethyl acetate (2×40 mL); the organic layers were combined, washed with water to neutral pH, dried over Na_2SO_4, the solvent was removed under reduced pressure. The residue was chromatographed on silica gel ($CHCl_3$). Light-yellow solid compound **10a** was obtained (0.401 g, 62%). M.p. 114—115 °C. Found (%): C, 60.82; H, 3.61; N, 13.01. $C_{22}H_{16}N_4O_6$. Calculated (%): C, 61.11; H, 3.73; N, 12.96. ^{1}H NMR ($(CD_3)_2SO$), δ: 8.21 (t, 1 H, H(2′), *J* = 1.9 Hz); 7.77 (t, 1 H, H(4′), *J* = 2.1 Hz); 7.65 (t, 1 H, H(6′), *J* = 2.1 Hz); 7.46 (t, 2 H, *m*-H, Ph(*y*), *J* = 8.1 Hz); 7.37 (t, 2 H, *m*-H, Ph(*x*), *J* = 8.1 Hz); 7.29 (t, 1 H, *p*-H, Ph(*y*), *J* = 7.5 Hz); 7.17 (t, 1 H, *p*-H, Ph(*x*), *J* = 7.3 Hz); 7.12 (d, 2 H, *o*-H, Ph(*y*), *J* = 8.5 Hz); 7.04 (d, 2 H, *o*-H, Ph(*x*), *J* = 8.5 Hz); 2.04 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 158.55 (C(5′)); 155.03 (*ipso*-C, Ph(*x*)); 154.26 (*ipso*-C, Ph(*y*)); 153.16 (C(3)); 149.17 (C(3′)); 146.70 (C(5)); 137.87 (C(1′)); 130.54 (*m*-C, Ph(*y*)); 130.40 (*m*-C, Ph(*x*)); 125.54 (*p*-C, Ph(*y*)); 124.56 (*p*-C, Ph(*x*)); 119.99 (*o*-C, Ph(*y*)); 116.85 (C(6′)); 115.33 (*o*-C, Ph(*x*)); 112.16 (C(4′)); 111.51 (C(2′)); 103.27 (C(4)); 7.71 (Me). IR, ν/cm^{-1}: 1536, 1344 (NO_2). MS, *m/z*: 432 $[M]^+$.

5-(4-Chlorophenylsulfanyl)-4-methyl-3-nitro-1-[5-nitro-3-(4-chlorophenylsulfanyl)phenyl]pyrazole (10b). K_2CO_3 (0.090 g, 0.65 mmol) was added to a solution of dinitropyrazole **3** (0.100 g, 0.30 mmol) and *p*-chlorobenzenethiol (0.087 g, 0.60 mmol) in acetonitrile (20 mL), the reaction mixture was refluxed in a flow of argon for 3 h (TLC). The reaction mixture was cooled to ~20 °C, poured into water (75 mL), acidified with HCl to pH 2—3; the precipitate that formed was filtered off, washed with water, and chromatographed on silica gel ($CHCl_3$). Light-yellow solid compound **10b** was obtained (0.076 g, 48%). M.p. 120—122 °C. Found (%): C, 49.09; H, 2.69; N, 10.11; S, 12.25. $C_{22}H_{14}Cl_2N_4O_4S_2$. Calculated (%): C, 49.54; H, 2.65; N, 10.50; S, 12.02. ^{1}H NMR ($(CD_3)_2SO$), δ: 8.26 (s, 1 H, H(6′)); 8.11 (s, 1 H, H(4′)); 7.76 (s, 1 H, H(2′)); 7.52 (s, 4 H, *o*-H, C_6H_4Cl-*p*(*y*) + + *m*-H, C_6H_4Cl-*p*(*y*)); 7.32 (d, 2 H, *m*-H, C_6H_4Cl-*p*(*x*), *J* = 8.1 Hz); 7.05 (d, 2 H, *o*-H, C_6H_4Cl-*p*(*x*), *J* = 8.1 Hz); 2.34 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 154.37 (C(3)); 148.25 (C(5′)); 140.20 (C(3′)); 138.63 (C(1′)); 134.90 (*o*-C, C_6H_4Cl-*p*(*y*)); 134.40 (*ipso*-C, C_6H_4Cl-*p*(*y*)); 133.93 (C(5)); 131.97 (*p*-C, C_6H_4Cl-*p*(*x*)); 131.56 (*ipso*-C, C_6H_4Cl-*p*(*x*)); 130.67 (C(2′)); 130.05 (*m*-C, C_6H_4Cl-*p*(*y*)); 129.49 (*m*-C, C_6H_4Cl-*p*(*x*)); 129.43 (*p*-C, C_6H_4Cl-*p*(*y*)); 128.93 (*o*-C, C_6H_4Cl-*p*(*x*)); 123.31 (C(4′)); 121.47 (C(4)); 118.87 (C(6′)); 9.93 (Me). IR, ν/cm^{-1}: 1540, 1348 (NO_2). MS, *m/z*: 536, 534, 532 (1 : 6 : 9) $[M]^+$.

5-Anilino-1-(3,5-dinitrophenyl)-4-methyl-3-nitropyrazole (11). K_2CO_3 (0.225 g, 1.6 mmol) was added to a solution of dinitropyrazole **3** (0.500 g, 1.5 mmol) and glycolanilide (0.223 g, 1.5 mmol) in acetonitrile (30 mL), the reaction mixture was refluxed for 4 h (TLC). The reaction mixture was cooled to ~20 °C, poured into water (120 mL), acidified with HCl to pH 2—3; the precipitate that formed was filtered off, washed with water, and chromatographed on silica gel ($CHCl_3$—Me_2CO (10 : 1)). Light-yellow compound **11** was obtained (0.325 g, 57%). M.p. 74—76 °C. Found (%): C, 50.04; H, 3.00; N, 22.19. $C_{16}H_{12}N_6O_6$. Calculated (%): C, 50.01; H, 3.15; N, 21.87. ^{1}H NMR ($(CD_3)_2SO$), δ: 8.87 (s, 2 H, H(2′)); 8.83 (s, 1 H, H(4′)); 8.58 (s, 1 H, NH); 7.15 (t, 2 H, *m*-H, Ph, *J* = 7.5 Hz); 6.78 (t, 1 H, *p*-H, Ph, *J* = 6.9 Hz); 6.70 (d, 2 H, *o*-H, Ph, *J* = 7.5 Hz); 2.15 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 154.30 (C(3)); 148.30 (C(3′)); 143.70 (*ipso*-C, Ph); 141.38 (C(5)); 138.65 (C(1′)); 129.45 (*m*-C, Ph); 123.54 (C(2′)); 119.98 (*p*-C, Ph); 117.94 (C(4′)); 114.23 (*o*-C, Ph); 110.19 (C(4)); 8.75 (Me). ^{15}N NMR ($(CD_3)_2SO$, δ: −16.8 (C(3′)NO_2); −175.3 (N(1)); −315.2 (NH). MS, *m/z*: 384 $[M]^+$.

([1-(3,5-Dinitrophenyl)-4-methyl-3-nitropyrazol-5-yl]sulfanyl)acetanilide (12). K_2CO_3 (0.455 g, 3.3 mmol) was added to a solution of dinitropyrazole **3** (1.002 g, 2.9 mmol) and thioglycolanilide (0.496 g, 3.0 mmol) in acetonitrile (50 mL), the reaction mixture was stirred for 20 h (TLC), poured into water (150 mL), acidified with HCl to pH 2—3; the precipitate that formed was filtered off, washed with water, and chromotographed on silica gel ($CHCl_3$). Light-yellow solid compound **12** was obtained (0.936 g, 69%). M.p. 192—194 °C. Found (%): C, 47.27; H, 3.05; N, 18.41; S, 7.08. $C_{18}H_{14}N_6O_7S$. Calculated (%): C, 47.16; H, 3.08; N, 18.33; S, 7.00. ^{1}H NMR ($(CD_3)_2SO$): δ, 9.89 (s, 1 H, NH); 8.94 (d, 2 H, H(2′), *J* = 2.2 Hz); 8.61 (t, 1 H, H(4′), *J* = 2.2 Hz); 7.22—7.13 (m, 4 H, *o*-H, Ph + *m*-H, Ph); 6.99 (t, 1 H, *p*-H, Ph, *J* = 6.6 Hz); 3.36 (s, 2 H, CH_2); 2.46 (s, 3 H, Me). ^{1}H NMR ($(CD_3)_2CO$), δ: 9.29 (s, 1 H, NH); 9.01 (d, 2 H, H(2′), *J* = 2.2 Hz); 8.70 (t, 1 H, H(4′), *J* = 2.2 Hz); 7.25 (d, 2 H, *o*-H, Ph, *J* = 8.1 Hz); 7.16 (t, 2 H, *m*-H, Ph, *J* = 7.9 Hz); 7.01 (t, 1 H, *p*-H, Ph, *J* = 6.6 Hz); 3.46 (s, 2 H, CH_2); 2.54 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 165.56 (CO); 154.50 (C(3)); 147.49 (C(3′)); 138.83 (C(1′)); 138.29 (*ipso*-C, Ph); 136.85 (C(5)); 128.52 (*m*-C, Ph); 126.16 (C(2′)); 123.66 (*p*-C, Ph); 121.63 (C(4)); 118.34 (C(4′) + *o*-C, Ph); 39.33 (CH_2); 10.16 (Me).

^{13}C NMR ($(CD_3)_2SO$), δ: 343 K): 165.42 (CO); 154.43 (C(3)); 147.74 (C(3′)); 139.05 (C(1′)); 138.27 (*ipso*-C, Ph); 136.84 (C(5)); 128.44 (*m*-C, Ph); 126.07 (C(2′)); 123.65 (*p*-C, Ph); 121.56 (C(4)); 118.66 (*o*-C, Ph); 118.37 (C(4′)); 39.34 (CH_2); 9.93 (Me). IR, ν/cm^{-1}: 1664 (CO); 1556, 1516, 1344 (NO_2). MS, *m/z*: 458 $[M]^+$.

1-(3,5-Dinitrophenyl)-5-ethoxy-4-methyl-3-nitropyrazole (13). A mixture of K_2CO_3 (0.230 g, 1.7 mmol) and dinitropyrazole **3** (0.512 g, 1.5 mmol) in ethanol (30 mL) was refluxed for 6 h (TLC). The reaction mixture was cooled to ~20 °C, poured into water (100 mL), acidified with HCl to pH 2—3; the precipitate that formed was filtered off, washed with water, and chromatographed on silica gel (n-C_6H_{14}—EtOAc (3 : 1)). Light-yellow compound **13** was obtained (0.137 g, 27%). M.p. 129—132 °C. Found (%): C, 43.36; H, 3.34; N, 20.40. $C_{12}H_{11}N_5O_7$. Calculated (%): C, 42.74; H, 3.29; N, 20.77. ^{1}H NMR ($(CD_3)_2SO$), δ: 8.91 (d, 2 H, H(2′), J = 2.2 Hz); 8.88 (t, 1 H, H(4′), J = 2.2 Hz); 4.35 (q, 2 H, CH_2, J = 6.8 Hz); 2.31 (s, 3 H, 4-Me); 1.34 (t, 3 H, $CH_2C\underline{H}_3$, J = 6.8 Hz). ^{13}C NMR ($(CD_3)_2SO$), δ: 153.50 (C(3)); 152.20 (C(5)); 148.52 (C(3′)); 138.08 (C(1′)); 122.33 (C(2′)); 117.58 (C(4′)); 101.02 (C(4)); 72.48 (CH_2); 15.02 ($CH_2\underline{C}H_3$); 7.87 (4-Me). IR, ν/cm^{-1}: 1552, 1544, 1536, 1344 (NO_2). MS, *m/z*: 337 $[M]^+$.

3-Methyl-2,6,8-trinitropyrazolo[1,5-*a*][3,1]benzothiazine-5-carboxanilide (14). K_2CO_3 (0.334 g, 2.4 mmol) was added to a solution of compound **12** (0.303 g, 0.67 mmol) in acetonitrile (20 mL), the reaction mixture was stirred for 48 h at ~20 °C (TLC), poured into water (100 mL), acidified with HCl to pH 2—3, and extracted with ethyl acetate (2×20 mL); the organic layers were combined, washed with water to neutral pH, dried over Na_2SO_4, the solvent was removed under reduced pressure. The residue was chromatographed on silica gel ($CHCl_3$—Me_2CO (10 : 1)). Orange compound **14** was obtained (0.198 g, 65%). M.p. 162—165 °C. Found (%): C, 47.30; H, 2.89; N, 18.75; S, 7.50. $C_{18}H_{12}N_6O_7S$. Calculated (%): C, 47.37; H, 2.65; N, 18.41; S, 7.03. ^{1}H NMR ($(CD_3)_2SO$), δ: 10.74 (s, 1 H, NH); 8.89, 8.82 (both s, 1 H + 1 H, H(7) + H(9), J = 2.2 Hz); 7.49 (d, 2 H, *o*-H, Ph, J = 8.1 Hz); 7.30 (t, 2 H, *m*-H, Ph, J = 8.1 Hz); 7.08 (t, 1 H, *p*-H, Ph, J = 7.7 Hz); 5.82 (s, 1 H, H(5)); 2.24 (s, 3 H, Me). ^{13}C NMR ($(CD_3)_2SO$), δ: 164.87 (CO); 155.13 (C(2)); 148.54 (C(6)); 147.49 (C(8)); 138.25 (*ipso*-C, Ph); 136.72 (C(9a)); 131.77 (C(3a)); 128.88 (*m*-C, Ph); 125.67 (C(5a)); 123.94 (*p*-C, Ph); 119.24 (*o*-C, Ph); 118.37, 117.52 (C(7) + C(9)); 113.60 (C(3)); 39.95 (C(5)); 9.08 (Me). IR, ν/cm^{-1}: 1696 (CO); 1548, 1340 (NO_2). MS, *m/z*: 456 $[M]^+$.

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