Pol. J. Chem., **75**, 1465–1474 (2001)

Azoles. Part 46 [1]. Uncommon Products from the Reactions of Some Nitroazoles with Tertiary Carbanions

by M.K. Bernard

Department of Organic Chemistry, Medical Academy, Gdańsk, 6, 80-780 Gdańsk, Poland
e-mail: bernard@amg.gda.pl

(Received April 6, 2001; revised June 8, 2001)

Some unusual products, like dimers, rotamers and ketone, were isolated from the reaction mixtures of vicarious nucleophilic substitution, involving nitroazoles and tertiary carbanions. Possible pathways of their formation are discussed.

Key words: azoles, vicarious nucleophilic substitution, carbanions

The vicarious nucleophilic substitution of hydrogen (VNS) is a versatile and well-established method for the introduction of a variety of substituents into electrophilic arenes and heteroarenes [2–4]. One of the important aspects of this method is the use of tertiary carbanion precursors as starting materials. Under typical conditions, *i.e.* KOH or t-BuOK as a base and dimethylsulfoxide (DMSO) or tetrahydrofuran (THF) as a solvent, tertiary carbanions replace only the para hydrogen atom to the nitro group in nitroarenes. When this position is occupied, the reaction usually does not occur at all. Although suitable conditions have been found to direct the substitution to the ortho position in nitrobenzene derivatives [5,6], the reaction of bulky carbanions with many nitroheteroarenes still causes problems [7].

During studies on the nucleophilic substitution in azoles we encountered difficulties in our efforts to obtain products from the VNS reaction of tertiary carbanions or bulky secondary ones and nitroazoles [8,9]. Even though we failed then to isolate pure products from the reaction mixtures, we usually observed that at least some amount of the starting materials was consumed. This prompted us to investigate closer the transformations that take place in these reactions.

RESULTS AND DISCUSSION

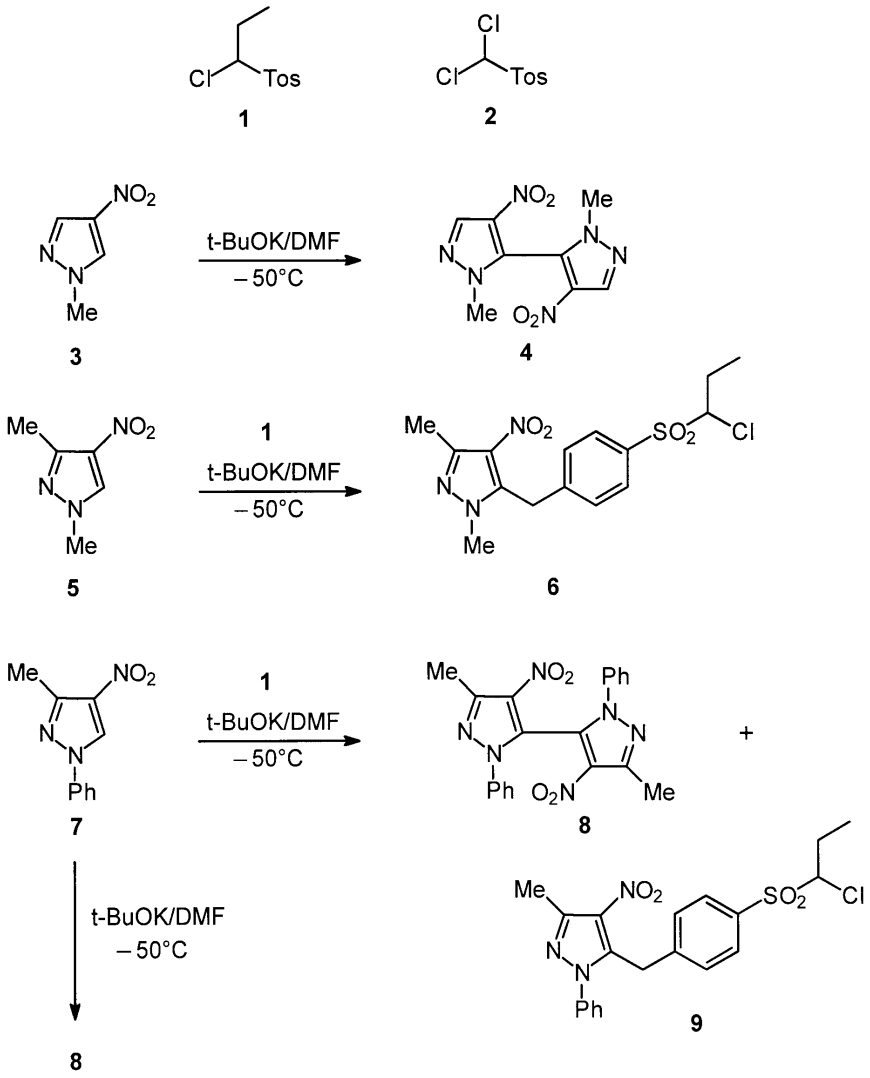
When pyrazoles **3**, **5** or **7** were treated with 1-chloropropyl tolyl sulphone **1** in the presence of t-BuOK in dimethylformamide (DMF) at low temperature, the VNS products were not detected in the reaction mixtures.

In reaction of pyrazole **3** and sulphone **1** a dimeric compound **4** was isolated in a low yield (14%) (Scheme 1). Its structure was confirmed by ^{1}H NMR and MS spectra. The first one showed only two singlets at 3.81 and 8.63 ppm that could be assigned to the N-methyl substituent and proton at C-3 of the pyrazole ring. The molecular ion

was found at m/z 252.0602, corresponding to a molecular formula of $C_8H_8N_6O_4$ and indicating that the mass of the product was twice that of the starting material less two mass units. Compound **4** was thus identified as 5,5′-bis(1,1′-dimethyl-4,4′-dinitro-pyrazole). A similar product, namely compound **8**, was isolated from the reaction mixture of pyrazole **7** and sulphone **1** (Scheme 1).

Having the structures of compounds **4** and **8** solved, it was clear that sulphone **1** was not involved in the reaction. Indeed, treatment of pyrazole **3** or **7** with t-BuOK in dimethylformamide at –50°C, without the starting material **1**, also led to the dimeric compounds **4** (yield 11%) or **8** (yield 22%).

Scheme 1



There are some precedents of the formation of dimers from heteroaromatic compounds. Such dimers were isolated from the reaction of lithium diisopropylamide with some azines [10] or when pyrazole derivatives were treated with butyllithium in the presence of copper(II) salts [11,12]. The dimers **4** and **8** can be formed as a result of the addition of pyrazole anion to another molecule of pyrazole, followed by oxidation of the intermediate σ adduct. Considering the literature data, this mechanism corresponds rather to oxidative nucleophilic substitution of hydrogen (ONSH) [13] than a single electron transfer (SET) pathway [10–12].

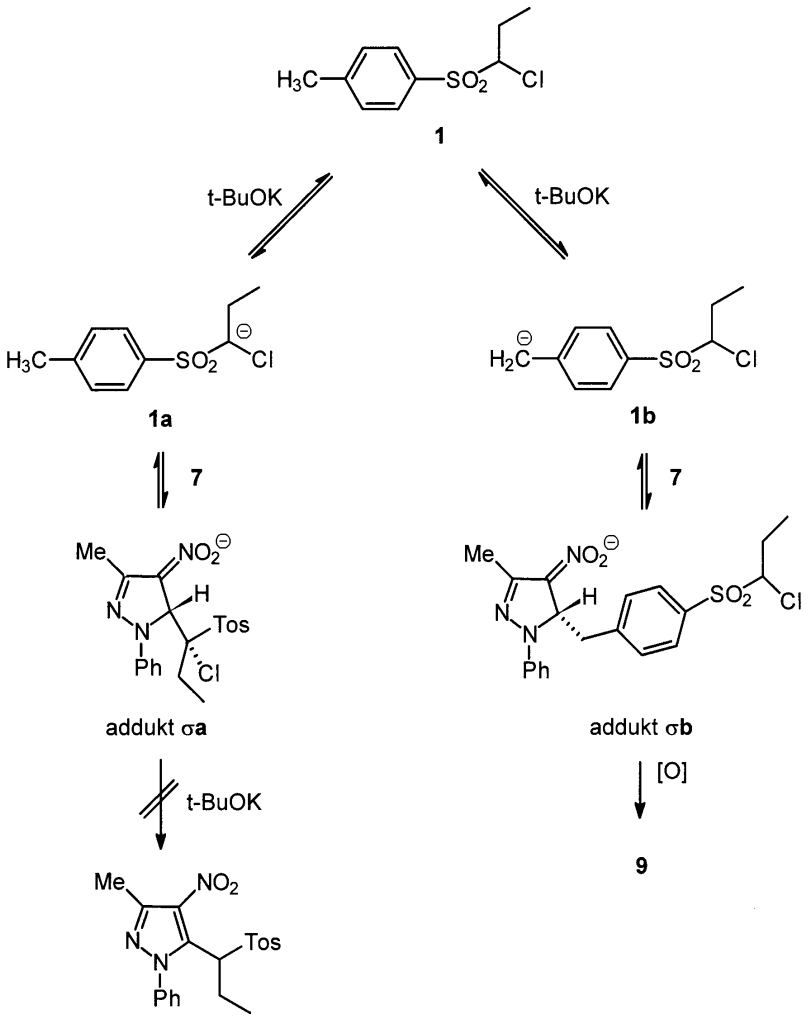
Apart from compound **8**, the reaction of pyrazole **7** and sulphone **1** afforded another unusual product **9** in a 6% yield (Scheme 1). Its molecular mass (m/z 433.0856) corresponded to a molecular formula of $C_{20}H_{20}ClN_3O_4S$ and was identical to that of the ONSH product. Moreover, the M+2 peak was approximately one-third intensity of the molecular ion peak, confirming the presence of one chlorine atom within the molecule. However, instead of the signal corresponding to the methyl group of the tosyl substituent, the ^{1}H NMR spectrum showed another singlet for two protons at 4.52 ppm. This singlet could only be assigned to an isolated methylene group. Irradiation of these protons led to a significant NOE on the multiplet at 7.30–7.32 ppm, corresponding to the ortho protons of the phenylene (tosyl) substituent, and a weaker effect on the ortho protons of the N-phenyl group. It was concluded that these protons belonged to a methylene bridge between the tosyl group and the C-5 position of the pyrazole ring; hence product **9** was identified as 5-[4-(1-chloropropylsulphonylbenzyl]-3-methyl-4-nitro-1-phenylpyrazole. A similar compound **6** was the only product isolated from the reaction mixture of pyrazole **5** and sulphone **1** (Scheme 1).

The formation of compounds **6** and **9** is connected with the inhibition of both the addition and particularly the elimination step. Even if the σ adduct could be produced, the steric obstacles would hinder the attainment of the antiperiplanar orientation required for the β-elimination. Though the methyl protons in compound **1** are less acidic than the methine one*, a carbanion formed by the abstraction of the methyl proton is also stabilized through the conjugation with the para sulphonyl group. Such carbanion **1b**, stabilized by a nonadjacent sulphonyl group, is present in the reaction medium in lower concentration than carbanion **1a**, but due to much less steric demands it reacts with the nitropyrazole more efficiently. As there is no leaving group at the reaction centre the formed σ adducts can be converted into products **6** or **9** only by oxidation (Scheme 2).

The use of carbanions, incorporating a distant stabilizing group in the VNS reaction, has already been described. Chhaly and Pritzkow reported on the reactions of 4-nitrobenzyl chloride and 4-nitrotoluene with 1,3-dinitrobenzene and 3-nitrochloro-

*The pK_a and pK_a^{II} values for p-$CH_3C_6H_4SO_2CH(Et)Cl$, *i.e.* CH and CH_3 acidities, have not been measured yet but are expected to be about 24–25 and 30, respectively, by analogy with the relative pK_a values of $PhSO_2CH_2Cl$ (23.4) and p-$PhSO_2C_6H_4CH_3$ (29.85), considering the effects of alkyl groups and chlorine atom [14,15].

Scheme 2

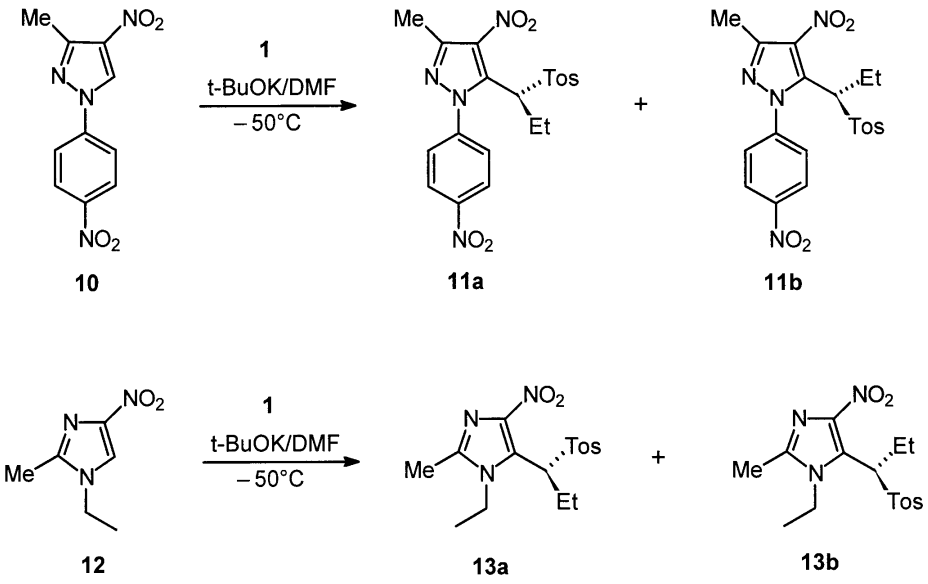


benzene [16]. Moreover, Iwasaki *et al.* described the oxidative coupling of methyl derivatives of pyridine and quinoline N-oxides with 4-nitrochlorobenzene and some azine N-oxides [17].

In our attempt to direct the reaction, involving pyrazole **7**, towards the VNS product sulphone **2** was applied as a carbanion precursor instead of compound **1**. The rationale behind this exchange was that the steric hindrance in the precursor **2** would be counterbalanced to some degree by a statistical factor favouring the elimination. However, the VNS product was not detected in the reaction mixture and dimer **8** was the only isolated compound.

The reaction of nitropyrazole **10** with sulphone **1** led to a product that existed in solution as a pair of rotamers **11a**/**11b** (Scheme 3). The ^{1}H NMR spectrum of com-

Scheme 3



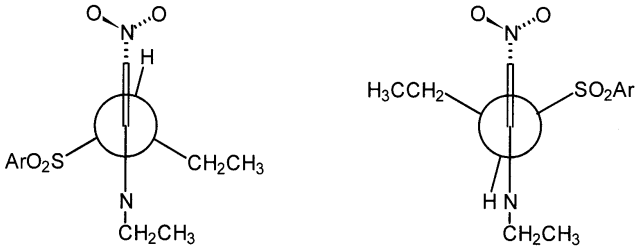
pound **11a**/**11b** showed two sets of resonances for all protons apart from the separated methyl groups. The ^{13}C NMR spectrum of pyrazole **11a**/**11b** also revealed two sets of carbon singlets, less distinctive in the aromatic region, but easily distinguishable in the aliphatic one.

We reasoned that it would be interesting to provide some physical data, like the value for rotational barrier, for rotamers **11a**/**11b**. However, we were unable to obtain well resolved ^{1}H NMR spectrum for conformers **11a**/**11b**. Furthermore, low solubility of these rotamers in organic solvents unabled the registration of temperature-dependent ^{13}C NMR spectra.

These difficulties turned our attention to a related heterocycle, namely imidazole. We have chosen 1-ethyl-2-methyl-4-nitroimidazole (**12**), easily available by alkylation of 2-methyl-4-nitroimidazole [18]. Compound **12** gave also two rotamers **13a**/**13b** upon treatment with sulphone **1**. Two sets of all signals were observed in the ^{1}H NMR spectrum, whereas some signals, probably corresponding to the isolated methyl carbons, were not doubled in the ^{13}C NMR one. The signals in the ^{1}H NMR spectrum were well separated. The integral levels showed that the isomers **13a**/**13b** were formed in a ratio of 1.8:1. Examination of the proton multiplicities and HH COSY plot allowed the assignment of all signals in the ^{1}H NMR spectrum. The CH_2 protons of the N-ethyl group did not appear as a typical quartet. Instead, the spectrum showed two separate sextets, representing one proton each, for the first rotamer, and a two-proton multiplet for the second one. This further splitting of the N-CH_2CH$_3$ protons is apparently due to the influence of the chiral centre at the imidazole C-5 atom.

The ^{1}H NMR spectra for compound **13a**/**13b** were recorded at various temperatures and the CH_2CH_3 triplets coalesced at 100°C (373 K). As the signals were separated at 20°C by 27 Hz, the value of rotation frequency was equal to 60 s^{-1}, and the free enthalpy of rotation, calculated from the logarithmic form of the Eyring equation, was 79.3 $kJmol^{-1}$. Although the rotation around the $C_{imidazole}$–CH bond is severely hampered, the C_5 substituent still rotates at room temperature and therefore the atropoisomers could not be isolated.

Inspection of the Dreiding models, as well as analysis of the ^{1}H NMR spectrum and HH COSY plot, revealed that two eclipsed conformations **13a** and **13b** (Figure 1) were the most stable. Rotamer **13a**, in which the methine proton eclipsed the C_4=C_5 double bond and the nitro group, was the prevailing one. The preference for this rotamer might be due to a weak bonding interaction between the nitro group and the methine proton.



13a **13b**

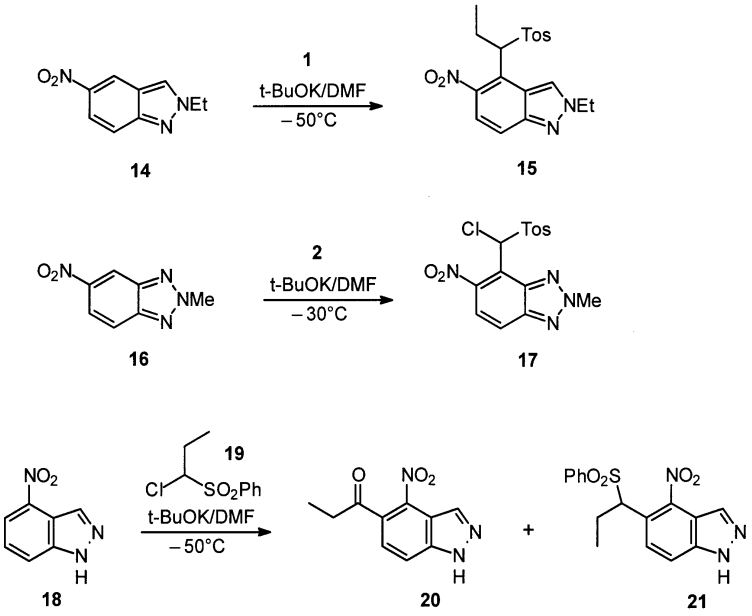
Figure 1. Eclipsed conformers of imidazoles **13a** and **13b** viewed along the $C_{5imidazole}$–CH axis.

For the following studies we have chosen nitro derivatives of indazole **14** and benzotriazole **16** (Scheme 4). These compounds have highly electrophilic dienoid structures. Despite that, upon treatment of compound **14** with sulphone **1** the yield of product **15** did not exceed 11% at best. Neither alterations of the reaction condition (DMF-THF mixtures instead of DMF and temperatures from –30 to –76°C) nor longer reaction time improved the yield. Along with product **11** always some amount of the starting materials was recovered, *e.g.* 30% of sulphone **1** and 41% of indazole **14** in the method described in the experimental section.

The VNS reaction of nitrobenzotriazole **16** with sulphone **19** was reported earlier [19]. However, the yield of the VNS product was only 41%. So we applied the carbanion precursor **2** for the VNS reaction involving nitrobenzotriazole **16** with the same reasoning behind as described above for pyrazole **7**. Nevertheless, the yield of the VNS product, namely compound **17**, was only 39%.

Finally, we investigated the reaction of 4-nitroindazole (**18**) with sulphone **19** (Scheme 4). Compound **19** was chosen instead of the precursor **1**, because insoluble aggregates were formed when the latter one was used for the VNS reaction involving indazole **18**. In 4-indazole (**18**) the substitution is possible in both ortho and para positions to the nitro group. However, when the reaction of indazole **18** and sulphone **19**

Scheme 4



was carried out in the KOH/DMSO system at room temperature, no products were detected in the reaction mixture and the starting materials were recovered quantitatively. In the presence of t-BuOK in DMF at –50°C two products **20** and **21** were formed in low yields (14 and 11%, respectively). Compound **21** was the expected substitution product, but the second one (**20**) had a different structure. The ^{1}H NMR spectrum showed a triplet at 1.18 ppm and a quartet at 2.51 ppm, corresponding to an ethyl substituent. Two doublets in the aromatic region confirmed that one of the positions in the benzene ring underwent substitution. A singlet at 200.2 ppm in the ^{13}C NMR spectrum could only be assigned to a carbonyl group. This supposition was evidenced by a strong absorption band in the IR spectrum at 1685 cm^{-1}. The molecular ion peak in the mass spectrum was observed at m/z 219.0626, corresponding to a molecular formula of $C_{10}H_9N_3O_3$. Thus, compound **20** was 4-nitro-5-(1-oxopropyl)indazole. Most probably this product could be formed by oxidation of the intermediate σ adduct and subsequent hydrolysis, but another pathway, which includes neighbouring nitro group participation cannot be excluded. It should be mentioned herein that controlled transformation of nitrobenzyl aryl sulphones into carbonyl derivatives, either by oxidation or electrophilic amination, has already been reported [20,21].

From the results described above we can draw some conclusions about the reactivity of nitroazoles in nucleophilic substitution involving tertiary carbanions. Albeit the geometry of pyrazole and imidazole rings are different from the benzene, the VNS reaction at the C-5 atom in 4-nitropyrazole and 4-nitroimidazole derivatives still resembles to some extent the substitution at the C-2 position in meta-substituted nitrobenzenes. The latter one does not occur with tertiary carbanions un-

less special conditions involving copper(I) tert-butoxide as a co-base are applied for the reaction [22]. The reaction of 4-nitroazole derivatives and tertiary carbanions does take place, but yields of the VNS products are low and the products are characterized by the restricted rotation about the sp^2–sp^3 (C_{azole}–CH) bond. Moreover, to direct the reaction towards the VNS products, the electrophilicity of the nitropyrazole derivatives should be enhanced by an additional electron-withdrawing substituent, like the N-(4-nitrophenyl) residue in compound **10**.

The relatively low reactivity of nitrobenzazoles towards tertiary carbanions is due to steric and stereoelectronic reasons. The *peri*-hydrogen at the C-3 position of indazoles or the unshared electron pair at the pyridinic nitrogen atom in benzotriazoles hinders either the carbanion approach to the C-4 position or the attainment of the antiperiplanar conformation required for β-elimination as well as proton removal from the σ adduct (compare the substitution in nitroquinolines [23]). On the other hand, carbanion approaching the C-7 position in N-unsubstituted benzazoles is repulsed by the negatively charged fragment of the heterocyclic ring.

EXPERIMENTAL

Flash chromatography (FC) was performed using silica gel 60, 230–400 mesh (Merck). Melting points were determined on a Boetius apparatus and are uncorrected. ^{1}H and ^{13}C NMR spectra were recorded respectively at 300 and 75 MHz on a Varian Mercury 300 instrument in DMSO-d_6. Low and high resolution mass spectra (MS) were run on an AMD 402 apparatus. IR spectra were recorded in KBr on a Specord 75-IR instrument. Starting materials were prepared according to known procedures: **1** and **19** [24], **2** [25], **3**, **5** and **10** [26], **7** [27], **12** [18], **14** [28], **16** [19]. Abbreviations: FC = flash chromatography, M = molecular ion.

Reactions of nitroazoles 3, 5, 7, 10, 12, 14, 16 or 18 with carbanion precursors 1 or 2. General procedure. A solution of nitroazole (1 mmol) and carbanion precursor (1 mmol) in dry DMF (3 cm^3) was added dropwise to a stirred solution of t-BuOK (336 mg, 3 mmol; **18**: 393 mg, 3.5 mmol) in DMF (2 cm^3) at –50°C (**16**: –30°C). Stirring was continued for 12 (**16**), 30 (**7** + **2**), 45 (**5**¸ **7** + **1**, **10**), 60 (**3**, **12**, **18**) or 120 minutes (**14**), the mixture was quenched with 2% HCl (40 cm^3) and extracted with dichloromethane (30 + 15 cm^3). The extract was washed with water, dried over $MgSO_4$, and the solvent was distilled off. A further work-up is given at the description of individual compounds.

5,5′-Bis(1,1′-dimethyl-4,4′-dinitropyrazole) (4). FC (hexanes – ethyl acetate 1:1) and crystallization from hexanes – diethyl ether (1:1) gave **4** as yellow prisms, m.p. 233–234°C. Yield: 14%. ^{1}H NMR δ 3.81 (s, 6H, 2 × CH_3), 8.63 (s, 2H, 2 × 3-H). MS: 252 (7, M), 251 (4), 222 (33, M–NO), 206 (100, M–NO_2), 176 (15), 153 (9), 121 (36); HRMS. Calcd. for $C_8H_8N_6O_4$: 252.0607. Found: 252.0602. Anal. Calcd.: C, 38.10; H, 3.20; N, 33.32. Found: C, 38.06; H, 3.01; N, 33.74.

5-[4-(1-Chloropropylsulphonyl)benzyl]-1,3-dimethyl-4-nitropyrazole (6). FC (hexanes – ethyl acetate 2:1) gave an oily fraction that was dissolved in diethyl ether – hexanes (1:1) and left in a closed vial for two weeks. Then the solvent was transferred from the deposited oil to another vial and left for one week. Compound **6** precipitated as yellow microcrystalline solid, m.p. 170–172°C. Yield: 2%. ^{1}H NMR δ 1.08 (t, *J* = 7 Hz, 3H, CH_2CH_3), 1.70–1.83 (m, 1H, CH_2), 2.25–2.38 (m, 1H, CH_2), 2.44 (s, 3H, 3-CH_3), 4.00 (s, 1H, CH_2), 5.66 (dd, *J* = 10 and 3 Hz, 1H, CH), 8.07–8.11 (m, 2H, phenyl), 8.14–8.17 (m, 2H, phenyl). MS 371 (2), 355 (43), 277 (14), 276 (17), 259 (17), 245 (51), 212 (100). Anal. Calcd. for $C_{15}H_{18}ClN_3O_4S$ (371.8): C, 48.45; H, 4.88; N, 11.30. Found: C, 48.79; 4.60; N, 11.22.

5,5′-Bis(3,3′-dimethyl-4,4′-dinitro-1,1′-diphenylpyrazole) (8). FC (hexanes – ethyl acetate 3:1; R_f = 0.51) and crystallization from 80% ethanol afforded compound **8** as yellow prisms, m.p. 270–272°C. Yield: 10% (from **7** + **1**) or 24% (from **7** + **2**). ^{1}H NMR δ 2.62 (s, 6H, 2 x CH_3), 6.82–6.85 (m, 4H, phenyl),

7.26–7.31 (m, 4H, phenyl), 7.38–7.41 (m, 2H, phenyl). MS 404 (17, M), 358 (100, M–NO_2), 341 (7), 312 (7), 311 (8). Anal. Calcd. for $C_{20}H_{16}N_6O_4$ (404.4): C, 59.40; H, 3.99; N, 20.78. Found: C, 59.61; H, 4.03; N, 20.88.

5-[4-(1-Chloropropylsulphonyl)benzyl]-3-methyl-4-nitro-1-phenylpyrazole (9). FC (hexanes – ethyl acetate 3:1; R_f = 0.39). The fraction containing the crude product **9** was dissolved in diethyl ether and an equal volume of hexanes was added. The resulted solution was left closed for two days and the precipitate was filtered off. Yield: 6%. Cream prisms, m.p. 92–94°C. ^{1}H NMR δ 1.03 (t, *J* = 7 Hz, 3H, CH_3), 1.62–1.72 (m, 1H, $\mathit{CH_2}CH_3$), 2.16–2.25 (m, 1H, $\mathit{CH_2}CH_3$), 2.56 (s, 3H, CH_3), 4.52 (s, 2H, CH_2Ar), 5.50 (dd, *J* = 10 and 3 Hz, 1H, CH), 7.30–7.32 (m, 2H, phenylene), 7.40–7.44 (m, 2H, phenyl), 7.51–7.54 (m, 3H, phenyl), 7.76–7.80 (m, 2H, phenylene). MS 435 (38, M+2), 433 (100, M), 416 (60), 399 (13), 388 (15), 339 (10), 338 (24), 323 (14). HRMS. Calcd. for $C_{20}H_{20}ClN_3O_4S$: 433.0863. Found: 433.0856. Anal. Calcd.: C, 55.36; H, 4.65; N, 9.68. Found: C, 55.71; H, 4.53; N, 9.41.

3-Methyl-4-nitro-1-(4-nitrophenyl)-5[1-(p-tolylsulphonyl)propyl]pyrazole (11a/11b). FC (hexanes – ethyl acetate 5:1) and crystallization from ethanol gave compound **11a**/**11b** (a mixture of rotamers in a ratio of 2:1) as pale yellow needles, m.p. 149–152°C. Yield: 23%. ^{1}H NMR δ 0.74 (t, *J* = 7 Hz, 3H, CH_3 **11b**), 1.00 (t, *J* = 7 Hz, 3H, CH_3 **11a**), 1.42–1.58 (m, 1H, CH_2 **11b**), 1.68–1.82 (m, 1H, CH_2 **11b**), 2.15–2.27 (m, 1H, CH_2 **11a**), 2.43 (s, 3H **11a** + 3H **11b**, CH_3-Ar), 2.49 (s, 3H **11a** + 3H **11b**, CH_3-Ar), 2.62–2.72 (m, 1H, CH_2 **11a**), 4.56 (dd, *J* = 10 and 6 Hz, 1H, CH **11a**), 5.70 (distorted dd, *J* cannot be calculated, 1H, CH **11b**), 7.28–7.31 (m, 2H, phenylene **11a**), 7.36 (s, 4H, phenylene **11a**), 7.48–7.51 (m, 2H, phenylene **11b**), 7.71–7.73 (m, 2H, phenylene **11b**), 7.98–8.00 (m, 2H, phenylene **11b**), 8.34–8.37 (m, 2H, phenylene **11a**), 8.44–8.47 (m, 2H, phenylene **11b**). ^{13}C NMR δ 11.4, 13.2, 14.0, 19.1, 20.4, 21.0 (6 x CH_3), 62.3 (CH **11b**), 63.9 (CH **11a**), 124.8, 125.0, 128.2, 129.4, 130.2, 133.0, 134.4, 134.6, 134.7, 141.2, 143.8, 145.7, 147.1, 147.9, 148.5; signals for CH_2 were overlapped with the DMSO multiplet. Anal. Calcd. for $C_{20}H_{20}N_4O_6S$ (444.5): C, 54.04; H, 4.54; N, 12.61. Found: C, 54.29; H, 4.69; N, 12.69.

1-Ethyl-2-methyl-4-nitro-5-[1-(p-tolylsulphonyl)propyl]imidazole (13a/13b). FC (hexanes – ethyl acetate 1:2) and crystallization from hexanes – ethyl acetate (2:1) gave compound **13a**/**13b** (a mixture of rotamers in a ratio of 1.8:1) as yellow prisms, m.p. 125–128°C. Yield: 19%. ^{1}H NMR δ 0.81 (t, *J* = 7.5 Hz, 3H, $CHCH_2\mathit{CH_3}$ **13b**), 0.90 (t, *J* = 7.5 Hz, 3H, $CHCH_2\mathit{CH_3}$ **13a**), 1.14 (t, *J* = 7.5 Hz, 3H, $NCH_2\mathit{CH_3}$ **13b**), 1.34 (t, *J* = 7.5 Hz, 3H, $NCH_2\mathit{CH_3}$ **13a**), 2.05–2.14 and 2.54–2.63 (2 × m, 2H, C-CH_2 **13b**), 2.17–~2.4 (m, 2H, C-CH_2 **13a**, partially overlapped by the CH_3 singlets) 2.36 and 2.42 (2 × s, 2 × 3 H, 2 × Ar-CH_3 **13b**), 2.38 and 2.44 (2 × s, 2 × 3 H, 2 × Ar-CH_3 **13a**), 3.83–3.97 (m, 2H, N-CH_2 **13b**), 4.24 and 4.54 (2 × sextet, 2H, N-CH_2 **13a**), 4.94 (dd, *J* = 11 and 5.5 Hz, 1H, CH **13b**), 5.70 (dd, *J* = 11 and 5.5 Hz, 1H, CH **13a**), 7.39–7.41 (m, 2H, phenylene **13b**), 7.41–7.43 (m, 2H, phenylene **13a**), 7.51–7.54 (m, 2H, phenylene **13b**), 7.57–7.59 (m, 2H, phenylene **13a**). ^{13}C NMR δ 11.2, 12.0, 13.2, 14.5, 15.2, 19.4, 20.5, 21.1, 41.2, 62.5, 62.7, 120.6, 122.9, 127.8, 128.5, 129.7, 129.8, 134.0, 134.3, 144.4, 145.0, 145.2, 145.3, 145.5, 146.0. Anal. Calcd. for $C_{16}H_{21}N_3O_4S$ (351.4): C, 54,68; H, 6.02; N, 11.96. Found: C, 55.06; H, 5.91; N, 11.95.

2-Ethyl-5-nitro-4-[1-(p-tolylsulphonyl)propyl]indazole (15). FC (hexanes – ethyl acetate 3:1) and crystallization from 80% ethanol gave compound **15** as cream needles, m.p. 156–158°C. Yield: 11%. ^{1}H NMR δ 0.74 (t, *J* = 7 Hz, 3H, C-$CH_2\mathit{CH_3}$), 1.44 (t, *J* = 7 Hz, 3H, N-$CH_2\mathit{CH_3}$), 2.30–2.62 (m, 2H, C-CH_2), 2.38 (s, 3H, Ar-CH_3), 4.53 (q, *J* = 7 Hz, 2H, N-CH_2), 5.28 (dd, *J* = 10.5 and 4.5 Hz, 1H, CH), 7.35–7.38 (m, 2H, phenylene), 7.44–7.47 (m, 2H, phenylene), 7.85 (d, *J* = 9 Hz, 1H, 7-H), 7.94 (d, *J* = 9 Hz, 1H, 6-H), 8.50 (s, 1H, 3-H). Anal. Calcd. for $C_{19}H_{21}N_3O_4S$ (387.5): C, 58.90; H, 5.46; N, 10.84. Found: C, 58.72; H, 5.50; N, 10.91.

2-Methyl-5-nitro-4-chloro(p-tolylsulphonyl)methylbenzotriazole (17). Crystallization from ethanol with charcoal afforded compound **17** as yellow needles, m.p. 234–235°C. Yield: 39%. ^{1}H NMR δ 2.43 (s, 3H, C-CH_3), 4.46 (s, 3H, N-CH_3), 7.15 (s, 1H, CH), 7.38–7.41 (m, 2H, phenylene), 7.53–7.56 (m, 2H, phenylene), 8.02 (d, *J* = 9 Hz, 1H, 7-H), 8.33 (d, *J* = 9 Hz, 1H, 6-H). Anal. Calcd. for $C_{15}H_{13}N_4O_4S$ (380.8): C, 47.31; H, 3,44; N, 14.71. Found: C, 47.58; H, 3.27; N, 14.52.

4-Nitro-5-(1-oxopropyl)indazole (20) and 4-nitro-5-(phenylsulphonylpropyl)indazole (21). FC (hexanes – ethyl acetate 2:1) and crystallization from 80% ethanol gave compound **20** (R_f = 0.45) as long yellow plates, m.p. 209–210°C, yield: 14%, and compound **21** (R_f = 0.21) as yellow needles, m.p. 194–196°C, yield: 11%. **20**: ^{1}H NMR δ 1.18 (t, *J* = 7 Hz, 3H, CH_3), 2.51 (q, *J* = 7 Hz, 2H, CH_2), 8.22 (d, *J* = 8 Hz, 1H, 6-H), 8.33 (d, *J* = 8 Hz, 1H, 7-H), 8.61 (s, 1H, 3-H), 14.07 (bs, 1H, NH). ^{13}C NMR δ 7.7 (CH_3),

31.7 (CH_2), 117.0, 117.6, 125.0, 128.2, 132.7, 138.6, 142.1, 200.2 (CO). IR (cm^{-1}) 3240 (NH), 1685 (CO), 1530 and 1345 (NO_2), 1205, 1155, 995, 935, 810. MS 219 (50, M), 190 (100, M–CH_2CH_3), 160 (19), 144 (20), 132 (21). HRMS. Calcd. for $C_{10}H_9N_3O_3$: 219.0644. Found: 219.0626. Anal. Calcd.: C, 54.79; H, 4.14; N, 19.17. Found: C, 54.56; H, 4.28; N, 19.30. **21**: ^{1}H NMR δ 0.77 (t, *J* = 7.5 Hz, 3H, CH_3), 2.22–2.37 (m, 2H, CH_2), 5.20 (t, *J* = 7.5 Hz, 1H, CH), 7.49–7.70 (m, 6H, phenyl + 7-H), 8.21 (d, *J* = 8 Hz, 1H, 6-H), 8.50 (d, *J* = 1.5 Hz, 1H, 3-H), 13.92 (bs, 1H, NH). ^{13}C NMR δ 11.0 (CH_3), 21.3 (CH_2), 65.8 (CH), 115.4, 118.4, 123.6, 125.3, 128.6, 129.1, 132.9, 134.3, 136.8, 139.5, 142.3. Anal. Calcd. for $C_{16}H_{15}N_3O_4S$ (345.4): C, 55.64; H, 4.38; N, 12.17. Found: C, 55.66; H, 4.21; N, 12.43.

REFERENCES

1. Part 45: Gzella A., *Acta Cryst. C*, (in press).
2. Mąkosza M. and Winiarski J., *Acc. Chem. Res.*, **20**, 282 (1987).
3. Mąkosza M., *Synthesis*, 103 (1991).
4. Mąkosza M. and Wojciechowski K., *Liebigs Ann./Recueil*, 1805 (1997).
5. Mudryk M. and Mąkosza M., *Tetrahedron*, **44**, 209 (1988).
6. Mąkosza M. and Kwast A., *J. Phys. Org. Chem.*, **11**, 341 (1998).
7. Mąkosza M. and Kwast E., *Bull. Pol. Acad. Sci. Chem.*, **35**, 287 (1987).
8. Bernard M.K., *Polish J. Chem.*, **71**, 1413 (1997).
9. Bernard M.K., *Tetrahedron*, **56**, 7273 (2000).
10. Plé N., Turck A., Couture K. and Queguiner G., *J. Org. Chem.*, **60**, 3781 (1995).
11. Lexy H. and Kaufmann T., *Chem. Ber.*, **113**, 2749 (1980).
12. Grimmett M.R. and Iddon B., *Heterocycles*, **37**, 2087 (1994).
13. Mąkosza M. and Staliński K., *Polish J. Chem.*, **73**, 151 (1999).
14. Bordwell F.G. and Clemens A.H., *J. Org. Chem.*, **47**, 2510 (1982).
15. Bordwell F.G., *Acc. Chem. Res.*, **21**, 456 (1988).
16. Chhaly L. and Pritzkow W., *J. Prakt. Chem./Chem.-Ztg.*, **336**, 558 (1994).
17. Iwasaki G., Wada K., Saeki S. and Hamana M., *Heterocycles*, **22**, 1811 (1984).
18. Liu Z.-Z., Chen H.-C., Cao S.-L. and Li R.-T., *Synth. Commun.*, **23**, 2611 (1993).
19. Bernard M.K., Szoja C. and Wrzeciono U., *Liebigs Ann. Chem.*, 755 (1990).
20. Wojciechowski K., *Synth. Commun.*, **27**, 135 (1997).
21. Wulf J.-P., Sienkiewicz K., Mąkosza M. and Schmitz E., *Liebigs Ann. Chem.*, 537 (1991).
22. Haglund O. and Nilsson M., *Synthesis*, 242 (1994).
23. Mąkosza M., Kinowski A., Danikiewicz W. and Mudryk B., *Liebigs Ann. Chem.*, 69 (1986).
24. Goliński J. and Mąkosza M., *Synthesis*, 823 (1978).
25. Middelbos W., Strating J. and Zwanenburg B., *Tetrahedron Lett.*, 351 (1971).
26. Bernard M.K., Mąkosza M., Szafran B. and Wrzeciono U., *Liebigs Ann. Chem.*, 545 (1989).
27. Grimmett M.R., Hartshorn S.R., Schofield K. and Weston J.B., *J. Chem. Soc., Perkin Trans. 2*, 1654 (1972).
28. Kamel M., Allman M.A., Abdel Hay F.I. and Osman M.A., *J. Prakt. Chem.*, **31**, 100 (1966).