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SYNTHESIS OF 1-ARYL-5-NITROBENZOTRIAZOLES*

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3-Aryl-1-(3-nitrophenyl)triazenes were obtained in the cyclization reaction of diazotized 3-nitroaniline with arylamines in the presence of dimethyl sulfoxide and potassium carbonate to give 1-aryl-5-nitrobenzotriazoles.

Keywords: benzotriazoles, diaryltriazenes, diazotization, intramolecular heterocyclization.

Triazoles are commonly used intermediates in organic synthesis and have found application in industry, agriculture, and medicine [1]. Many triazoles and their derivatives have high biological activity, including antitumor activity [2, 3].

The synthesis of 1,2,3-benzotriazoles has been accomplished by various methods including diazotization of *o*-diaminoarenes, reaction of aryl azides with unsaturated compounds, and heterocyclization of *o*-amino-*N*-nitrosoarylamines or arylazobenzenes containing amino, nitro, or azido groups in the *ortho* position [4]. The solid-phase synthesis of *N*-substituted 1*H*-benzotriazoles from *ortho*-halo- and *ortho*-nitroaryltriazenes has been described by Zimmermann and Bräse [5].

In the previous work [6], we developed a synthesis for triazoles using 9,10-anthraquinone derivatives. 3-Arylanthra[1,2-*d*]triazole-6,11-diones were obtained by the intramolecular heterocyclization of 1-aryl-3-anthraquinonyltriazenes entailing intramolecular nucleophilic substitution of hydrogen in the presence of a basic catalyst.

In the present work, we have studied the feasibility of forming the triazole ring using 1,3-diaryltriazenes. We synthesized a series of 1,3-diaryltriazenes **1a-d** containing a nitro group at position 3 in one of the aryl residues. The synthesis of diaryltriazenes was carried out by the diazotization of 3-nitroaniline and subsequent reaction of the resultant diazonium salt with a corresponding primary arylamine in pyridine.

The composition and structure of the obtained diaryltriazenes were confirmed by physicochemical methods. The ^{1}H NMR spectra of diaryltriazenes **1b**,**c** show a doubling of the signals both for the triazene and methyl group protons, indicating the existence of diphenyltriazenes containing an electron-withdrawing substituent and an electron-donor substituent in two tautomeric forms. The spectra of diaryltriazenes **1a**,**d**, which combine a strong electron-withdrawing substituent and a weaker electron-withdrawing substituent, show

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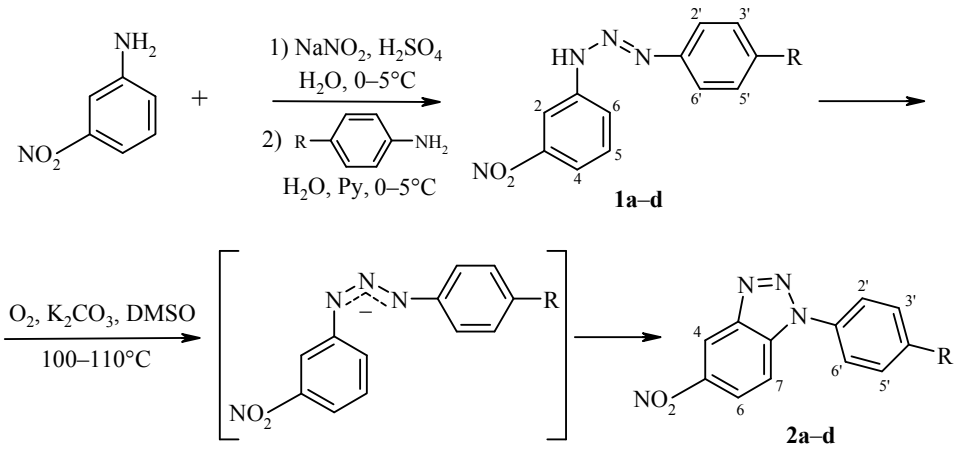
broadened signal for the protons of the triazene group at 12.7-13.0 ppm. The broadening of this signal as well as signals of the aromatic protons also suggests the existence of these compounds in two tautomeric forms. We would like to mention that similar results for diaryltriazenes with electron-withdrawing substituents have been described by Čimbora-Zovko et al. [7].

Obtained 3-aryl-1-(3-nitrophenyl)triazenes **1a-d** undergo cyclization in the presence of potassium carbonate in dimethyl sulfoxide over several hours to give 1-arylbenzotriazoles **2a-d** in moderate yield.



a R = H, **b** R = Me, **c** R = OMe, **d** R = Cl

The structure of the obtained benzotriazoles **2a-d** was confirmed by physicochemical methods. The formation of these triazoles apparently proceeds as a result of deprotonation of diaryltriazenes **1a-d** and subsequent nucleophilic substitution of the hydrogen atom, activated by a nitro group in the *para* position.

The nucleophilic substitution of hydrogen in this new intramolecular cyclization proceeds with the involvement of atmospheric oxygen. An independent experiment showed that rapid bubbling of air through the reaction mixture reduces the reaction time, while the rate of cyclization is reduced by a factor of 15 under an argon atmosphere.

Thus, we have found that the intramolecular cyclization of diaryltriazenes entailing intramolecular substitution of a hydrogen atom proceeds not only for arylanthraquinolinyltriazene [6] but also for benzene derived compounds.

EXPERIMENTAL

The IR spectra were recorded on a Bruker IFS-66 spectrometer in KBr pellets. The ^{1}H NMR spectra were recorded on a Bruker DRX-500 spectrometer (500 MHz) in DMSO-d_6 with TMS as internal standard. The electronic absorption spectra were recorded on an Evolution 300 spectrometer in toluene. The mass spectra were recorded on a Finnigan MAT 8200 spectrometer with direct sample inlet and 70 eV ionizing electron energy. The elemental analysis was carried out on a EURO EA 3000 apparatus. The melting points were determined on a Boetius microscopic melting point apparatus. The course of the reactions and purity of the products were monitored by thin-layer chromatography on Silufol UV-254 plates using 9:1 toluene–ethyl acetate as the eluent. The products were recrystallized from 10:1 ethanol–DMF.

3-(3-Nitrophenyl)-1-phenyltriazene (1a). A solution of 3-nitroaniline (1.00 g, 7 mmol) in concentrated sulfuric acid (1.5 ml) and water (2 ml) was diazotized by adding $NaNO_2$ (0.50 g, 7 mmol) in water (1 ml) over 1 h at 0-5°C [8]. Then aniline (0.64 ml, 7 mmol) in pyridine (35 ml) was added over 2 h to the resultant solution of 3-nitrophenyldiazonium salt at the same temperature. An equal volume of water was added to the reaction

mixture. The yellow precipitate formed was filtered off, washed with water and ethanol, dried in air, and recrystallized. Yield 0.89 g (51%), mp 138°C. IR spectrum, ν, cm^{-1}: 3289 (NH). UV spectrum, λ_{max}, nm (log ε): 344 (4.30). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.17-7.27 (1H, m, H-4'); 7.43 (2H, t, *J* = 8.0, H-3',5'); 7.46-7.55 (2H, m, H-2',6'); 7.66 (1H, t, *J* = 8.0, H-5); 7.79-7.88 (1H, m, H-6); 7.88-7.99 (1H, m, H-4); 8.13 (1H, s, H-2); 12.73 (1H, br. s, NH). Mass spectrum, *m/z* (I_{rel}, %): 242 $[M]^+$ (4), 77 $[C_6H_5]^+$ (100). Found, %: C 59.10; H 4.09; N 23.42. $C_{12}H_{10}N_4O_2$. Calculated, %: C 59.50; H 4.16; N 23.13.

Triazenes **1b-d** were obtained analogously.

1-(4-Methylphenyl)-3-(3-nitrophenyl)triazene (1b). Yield 1.14g (64%), mp 103-105°C. IR spectrum, ν, cm^{-1}: 3278 (NH). UV spectrum, λ_{max}, nm (log ε): 348 (4.26). ^{1}H NMR spectrum, δ, ppm (*J*, Hz) (tautomer ratio 7:3): 2.28 (0.9H, s, CH_3); 2.35 (2.1H, s, CH_3); 7.27 (2H, d, *J* = 8.0, H-3',5'); 7.48 (2H, d, *J* = 8.0, H-2',6'); 7.62 (1H, t, *J* = 8.0, H-5); 7.74 (1H, d, *J* = 8.0, H-6); 7.83 (1H, d, *J* = 8.0, H-4); 8.07 (1H, s, H-2); 12.68 (0.7H, s, NH); 12.82 (0.3H, s, NH). Mass spectrum, *m/z* (I_{rel}, %): 256 $[M]^+$ (6), 91 $[C_7H_7]^+$ (100). Found, %: C 60.64; H 4.56; N 21.63. $C_{13}H_{12}N_4O_2$. Calculated, %: C 60.93; H 4.72; N 21.86.

1-(4-Methoxyphenyl)-3-(3-nitrophenyl)triazene (1c). Yield 0.99 g (52%), mp 126-128°C. IR spectrum, ν, cm^{-1}: 3260 (NH). UV spectrum, λ_{max}, nm (log ε): 353 (4.32). ^{1}H NMR spectrum, δ, ppm (*J*, Hz) (tautomer ratio 17:3): 3.73 (0.45H, s, OCH_3); 3.78 (2.55H, s, OCH_3); 7.02 (2H, d, *J* = 8.0, H-3',5'); 7.54 (2H, d, *J* = 8.0, H-2',6'); 7.61 (1H, t, *J* = 8.0, H-5); 7.72 (1H, d, *J* = 8.0, H-6); 7.80 (1H, d, *J* = 8.0, H-4); 8.04 (1H, s, H-2); 12.55 (0.85H, s, NH); 12.80 (0.15H, s, NH). Mass spectrum, *m/z* (I_{rel}, %): 272 $[M]^+$ (7), 107 $[C_7H_7O]^+$ (100). Found, %: C 57.28; H 4.26; N 20.40. $C_{13}H_{12}N_4O_3$. Calculated, %: C 57.35; H 4.44; N 20.58.

1-(4-Chlorophenyl)-3-(3-nitrophenyl)triazene (1d). Yield 0.92 g (48%), mp 125°C. IR spectrum, ν, cm^{-1}: 3281 (NH). UV spectrum, λ_{max}, nm (log ε): 349 (4.32). ^{1}H NMR spectrum , δ, ppm (*J*, Hz): 7.48-8.11 (8H, m, H Ar); 12.93 (1H, br. s, NH). Mass spectrum, *m/z* (I_{rel}, %): 276 [M]+ (10), 111 $[C_6H_4Cl]^+$ (100). Found, %: C 52.13; H 3.23; N 20.49. $C_{12}H_9ClN_4O_2$. Calculated, %: C 52.09; H 3.28; N 20.25.

5-Nitro-1-phenylbenzotriazole (2a). A reaction mixture containing triazene **1a** (0.85 g, 3.5 mmol), potassium carbonate (1.40 g, 10.0 mmol), and DMSO (5 ml) was maintained at 100-110°C with vigorous stirring for several hours until the starting substrate disappeared. Three volumes of water were added. The brown precipitate was filtered off, washed with water and ethanol, and dried in air. Yield 0.43 g (51%), mp 128-130°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.66 (1H, t, *J* = 8.0, H-4'); 7.71-7.77 (2H, m, H-3',5'); 7.89-7.93 (2H, m, H-2',6'); 8.12 (1H, d, *J* = 9.2, H-7); 8.45 (1H, d. d, *J* = 9.2, *J* = 3.0, H-6); 9.15 (1H, d, *J* = 3.0, H-4). Mass spectrum, *m/z* (I_{rel}, %): 240 $[M]^+$ (10), 166 $[M\text{-}N_2\text{-}NO_2]^+$ (36), 77 $[C_6H_5]^+$ (100), 51 $[C_4H_3]^+$ (69). Found, %: C 60.30; H 3.33; N 23.04. $C_{12}H_8N_4O_2$. Calculated, %: C 60.00; H 3.36; N 23.32.

Benzotriazoles **2b-d** were obtained analogously.

1-(4-Methylphenyl)-5-nitrobenzotriazole (2b). Yield 0.38 g (43%), mp 197-210°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 2.45 (3H, s, CH_3); 7.53 (2H, d, *J* = 8.8, H-3',5'); 7.78 (2H, d, *J* = 8.8, H-2',6'); 8.08 (1H, d, *J* = 9.2, H-7); 8.44 (1H, d, *J* = 9.2, H-6); 9.16 (1H, s, H-4). Mass spectrum, *m/z* (I_{rel}, %): 254 $[M]^+$ (16), 180 $[M\text{-}N_2\text{-}NO_2]^+$ (100), 152 $[M\text{-}N_2\text{-}NO_2\text{-}H\text{-}HCN]^+$ (25), 91 $[C_7H_7]^+$ (28), 65 $[C_5H_5]^+$ (27). Found, %: C 61.74; H 3.96; N 22.44. $C_{13}H_{10}N_4O_2$. Calculated, %: C 61.41; H 3.96; N 22.04.

1-(4-Methoxyphenyl)-5-nitrobenzotriazole (2c). Yield 0.59 g (63%), mp >360°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.89 (3H, s, OCH_3); 7.25 (2H, d, *J* = 8.8, H-3',5'); 7.81 (2H, d, *J* = 8.8, H-2',6'); 8.02 (1H, d, *J* = 9.2, H-7); 8.44 (1H, d, *J* = 9.2, H-6); 9.15 (1H, s, H-4). Mass spectrum, *m/z* (I_{rel}, %): 270 $[M]^+$ (28), 242 $[M\text{-}N_2]^+$ (15), 227 $[M\text{-}N_2\text{-}CH_3]^+$ (73), 181 $[M\text{-}N_2\text{-}CH_3\text{-}NO_2]^+$ (100), 153 $[M\text{-}N_2\text{-}CH_3\text{-}NO_2\text{-}CO]^+$ (64), 92 $[C_6H_4O]^+$ (26), 77 $[C_6H_5]^+$ (22). Found, %: C 57.61; H 3.69; N 20.50. $C_{13}H_{10}N_4O_3$. Calculated, %: C 57.78; H 3.73; N 20.73.

1-(4-Chlorophenyl)-5-nitrobenzotriazole (2d). Yield 0.53 g (56%), mp >360°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.81 (2H, d, *J* = 8.7, H-2',6'); 7.97 (2H, d, *J* = 8.7, H-3',5'); 8.14 (1H, d, *J* = 9.1, H-7); 8.47 (1H, dd, *J* = 9.1, *J* = 2.0, H-6); 9.19 (1H, d, *J* = 2.0, H-4). Mass spectrum, *m/z* (I_{rel}, %): 274 $[M]^+$ (61), 200 $[M\text{-}N_2\text{-}NO_2]^+$ (99), 165 $[M\text{-}N_2\text{-}NO_2\text{-}Cl]^+$ (84), 111 $[C_6H_4Cl]^+$ (100). Found, %: C 52.45; H 2.56; N 19.96. $C_{12}H_7ClN_4O_2$. Calculated, %: C 52.47; H 2.57; N 20.40.

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