Chemistry of Heterocyclic Compounds, Vol. 44, No. 11, 2008

SYNTHESIS OF 1,3-DIAZAPYRENES AND 1,3,7-TRIAZAPYRENES BY THE REACTION OF 1,8-NAPHTHALENEDIAMINE WITH TRIAZINE IN THE PRESENCE OF CARBONYL COMPOUNDS OR BENZONITRILE IN POLYPHOSPHORIC ACID*

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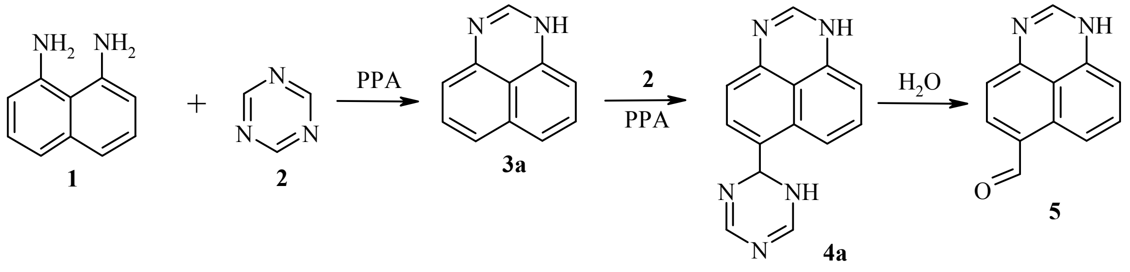
A novel three-component synthesis has been developed for 1,3-diazapyrenes based on the reaction of 1,8-naphthalenediamine with triazine and carbonyl compounds in polyphosphoric acid (PPA). The use of benzonitrile in place of the carbonyl compounds in this reaction gives 6-phenyl-1,3,7-triazapyrenes.

Keywords: 1,3-diazapyrenes, 1,8-naphthalenediamine, perimidines, PPA, 1,3,7-triazapyrenes, 1,3,5-triazine, annelation.

We have previously [1, 2] developed a method for the acylation (formylation) of perimidines based on their reaction with 1,3,5-triazines in PPA*[2].

In the case of synthesis of 1,2,3,7-tetraazapyrenes using this system of reagents the *peri* annelation of a pyridine ring was shown to be possible [4]. It was of interest to broaden this synthetic potential by the addition of an further reagent. In this report we discuss the reaction of 1,8-naphthalenediamine with triazine **2** in PPA in the presence of carbonyl compounds and benzonitrile.

The reaction of diamine **1** with triazine **2** gives the perimidine **3a** [5] which, as we have recently shown [1, 2], gives the perimidine-6(7)-carbaldehyde (**5**) after reaction with compound **2** in PPA and then treatment of the reaction mixture with water. The compound **4a** was postulated as intermediate.



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* Dedicated to one of the best Russian chemists A. F. Pozharskii on his 70th jubilee.

*[2] PPA with an 86% content of P_2O_5 was prepared by the method [3]

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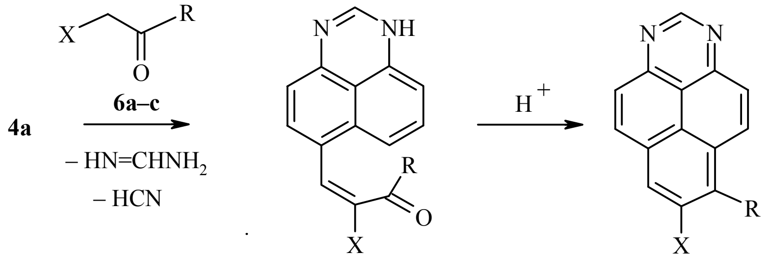
We have suggested that the first two stages can be combined. In fact, the reaction of diamine **1** with triazine **2** in the ratio 1:3 gives compound **5** after hydrolysis of the reaction mixture in near quantitative yield.

$$\mathbf{1} \xrightarrow[\text{2) } H_2O]{\text{1) } \mathbf{2}\text{/PPA}} \mathbf{5}$$

We have further proposed that opening of the dihydrotriazine ring in the intermediate **4a** can be brought about not only by water but also by other nucleophilic reagents, e.g. the carbonyl compounds **6**. Moreover, as a result of the presence of an electrophilic center (the carbonyl group) in the intermediate material **7** a cyclization can occur resulting in formation of the 1,3-diazapyrenes **8**.



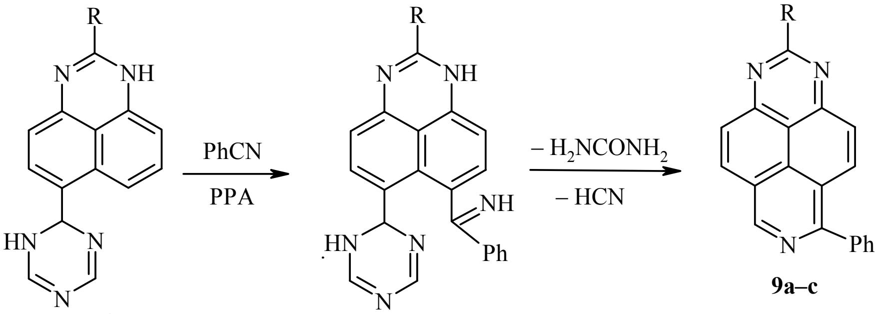
7a–c **8a–c**

6–8 **a** R = Ph, X = H, **b** R = Me, X = COOEt, **c** R = Me, X = COMe

In fact, the reaction of diamine **1** with triazine **2** and the carbonyl compounds **6a-c** (molar ratio 1:3:3) in PPA gives the 1,3-diazapyrenes in 57-68% yields.

$$\mathbf{1} + \mathbf{2} + \mathbf{6a{-}c} \xrightarrow[\text{60–70°C}]{\text{PPA}} \mathbf{8a{-}c}$$

It is known that the reaction of diamine **1** with benzonitrile leads to formation of the 2,6,8-triphenyl-1,3,7-triazapyrene [6] hence it can be expected that compound **4a** will react with benzonitrile to give the 6-phenyl-1,3,7-triazapyrene **9a**.



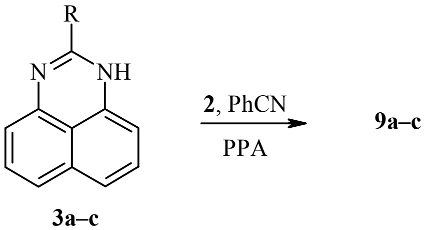
4a–c **9a–c**

4, **9** **a** R = H, **b** R = Me, **c** R = Ph

The yield of compound **9a** in the three component reaction of compounds **1**, **2**, and benzonitrile in PPA is 72%.

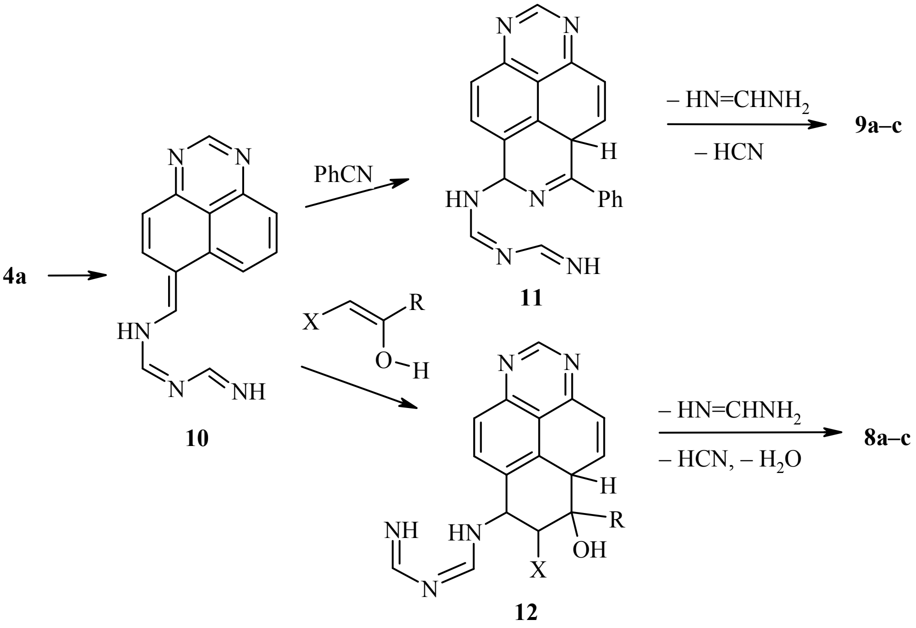
$$\mathbf{1} \xrightarrow[\text{PPA}]{\mathbf{2}\text{, PhCN}} \mathbf{9a}$$

Bearing in mind that the intermediate compounds **4a-c** can be prepared from the perimidines **3a-c** we also developed a method for the synthesis of triazapyrenes **9a-c** *via* a three component reaction of compounds **3a-c**, **2** and benzonitrile in PPA in 71-75% yield.



3a–c
3, **9** **a** R = H, **b** R = Me, **c** R = Ph

For the reaction given above an alternative mechanism can be proposed with a stage of annelation of the ring which includes formation of the intermediate **10** *via* opening of the dihydrotriazine ring in compound **4** and a subsequent Diels-Alder reaction to form the intermediates **11** and **12**.



EXPERIMENTAL

^{1}H NMR spectra were recorded on a Bruker WP-200 (200 MHz) instrument using $CDCl_3$ (compounds **8a-c, 9b,c**) or DMSO-d_6 (compound **9a**) with TMS as internal standard and mass spectra were taken on a MAT-311A instrument. Monitoring of the course of the reaction and the purity of the synthesized compounds was carried out on Silufol UV-254 plates using ethyl acetate solvent. Column chromatography was carried out on L 40/100 silica gel using ethyl acetate eluent.

Perimidine-6(7)-carbaldehyde (5). A mixture of 1,8-naphthalenediamine (0.154 g, 1 mmol) and 1,3,5-triazine (0.243 g, 3 mmol) in PPA (3-4 g) was stirred vigorously for 9 h at 60-70ºC, the reaction mixture was poured into water (30 ml), basified by ammonia solution to pH ~ 7-8, and the crystals formed after cooling were extracted with ethyl acetate (3×50 ml). The solvent was evaporated. Yield 91%; mp 212-214ºC (acetic acid); mp 212-214ºC [7]. A sample mixed with a known sample did not give a depression of melting point. The ^{1}H NMR spectrum was identical to that given in [7].

Synthesis of the 1,3-Diazapyrenes 8a-c (General Method). A mixture of 1,8-naphthalenediamine (0.154 g, 1 mmol), 1,3,5-triazine (0.243 g, 3 mmol), and the corresponding carbonyl compound (3 mmol) in PPA (3-4 g) was stirred vigorously for 9h at 60-70ºC. The reaction mixture was poured into water (30 ml), basified using ammonia solution to pH ~ 7-8, and the crystals or oil formed after cooling were extracted with ethyl acetate (3 x 50 ml). Solvent was evaporated and the residue was chromatographed.

6-Phenyl-1,3-diazapyrene (8a). Yield 0.16 g (57%); mp 193-195ºC (ethyl acetate). ^{1}H NMR spectrum, δ, ppm (J, Hz): 7.59-7.64 (5H, m, C_6H_5); 8.15 (1H, d, $J_{7,8}$ = 7.72, H-7); 8.32 (1H, d, $J_{4,5}$ = 9.4, H-5); 8.41 (1H, d, $J_{7,8}$ = 7.7, H-8); 8.48 (1H, d, $J_{9,10}$ = 9.4, H-9); 8.76 (1H, d, $J_{4,5}$ = 9.4, H-4); 8.98 (1H, d, $J_{9,10}$ = 9.4, H-10); 9.76 (1H, s, H-2). Found, %: C 85.82; H 4.25; N 8.93. $C_{20}H_{12}N_2$. Calculated, %: C 85.69; H 4.32; N 9.99.

Ethyl 6-Methyl-1,3-diazapyrene-7-carboxylate (8b). Yield 0.197 g (68%); mp 153-154ºC (ethyl acetate). ^{1}H NMR spectrum, δ, ppm (J, Hz): 1.52 (3H, t, J = 6.8, $C\underline{H}_3CH_2$); 3.26 (3H, s, CH_3); 4.55 (2H, q, J = 6.9, $CH_3C\underline{H}_2$); 8.22 (1H, d, $J_{9,10}$ = 9.5, H-9); 8.31 (1H, d, $J_{4,5}$ = 9.5, H-5); 8.55 (1H, d, $J_{9,10}$ = 9.5, H-10); 8.85 (1H, s, H-8); 8.93 (1H, d, $J_{4,5}$ = 9.5, H-4); 9.80 (1H, s, H-2). Found, %: C 74.58; H 4.81; N 9.58. $C_{18}H_{14}N_2O_2$. Calculated, %: C 74.47; H 4.86; N 9.65.

7-Acetyl-6-methyl-1,3-diazapyrene (8c). Yield 0.266 g (64%); mp 161-163ºC (ethyl acetate). ^{1}H NMR spectrum, δ, ppm (J, Hz): 2.86 (3H, s, $COCH_3$); 3.14 (3H, s, CH_3); 8.23 (1H, d, $J_{9,10}$ = 9.5, H-9); 8.31 (1H, d, $J_{4,5}$ = 9.5, H-5); 8.54 (1H, d, $J_{9,10}$ = 9.5, H-10); 8.55 (1H, s, H-8); 8.90 (1H, d, $J_{4,5}$ = 9.5; H-4); 9.83 (1H, s, H-2). Found, %: C 78.58; H 4.59; N 10.71. $C_{17}H_{12}N_2O$. Calculated, %: C 78.44; H 4.65; N 10.76.

Synthesis of 6-Phenyl-1,3,7-triazapyrene (9a) from 1,8-Naphthalenediamine. A mixture of 1,8-naphthalenediamine (0.154 g, 1 mmol), 1,3,5-triazine (0.243 g, 3 mmol), and benzonitrile (0.515 g, 5 mmol) in PPA (3-4 g) was vigorously stirred for 8 h at 60-70ºC. The reaction mixture was poured into water (30 ml), basified with ammonia solution to pH ~ 7-8, and the crystals formed after cooling were extracted with ethyl acetate (3×50 ml). Solvent was evaporated and the residue was chromatographed.

Synthesis of 2-R-6-Phenyl-1,3,7-triazapyrenes 9a-c from Perimidines 3a-c (General Method). A mixture of the corresponding perimidine (1 mmol), 1,3,5-triazine (0.243 g, 3 mmol), and benzonitrile (0.515 g, 5 mmol) in PPA (3-4 g) was vigorously stirred for 8 h at 60-7-ºC. The reaction mixture was poured into water (30 ml), basified with aqueous ammonia solution to pH ~ 7-8, and the crystals or oil formed after cooling were extracted with ethyl acetate (3×50 ml). Solvent was evaporated and the residue was chromatographed.

6-Phenyl-1,3,7-triazapyrene (9a). Yield from 1,8-naphthalenediamine 0.2 g (72%), from the perimidine 0.211 g (75%); mp 174-176ºC (nonane). ^{1}H NMR spectrum, δ, ppm (J, Hz): 7.68 (3H, m, 3,4,5-C_6H_5); 7.91 (2H, br. d, J = 8.0, 2,6-C_6H_5); 8.29 (1H, d, $J_{9,10}$ = 9.5, H-10); 8.33 (1H, d, $J_{4,5}$ = 9.1, H-4); 8.75 (1H, d, $J_{9,10}$ = 9.5, H-9); 8.91 (1H, d, $J_{4,5}$ = 9.1, H-5); 9.86 (1H, s, H-8); 9.89 (1H, s, H-2). Mass spectrum (70 eV), m/z (I_{rel}, %): 281 $[M]^+$ (100). Found, %: C 81.27; H 3.87; N 14.86. $C_{19}H_{11}N_3$. Calculated, %: C 81.12; H 3.94; N 14.94.

2-Methyl-6-phenyl-1,3,7-triazapyrene (9b). Yield 0.21 g (71%); mp 246-248ºC (nonane). ^{1}H NMR spectrum, δ, ppm (J, Hz): 3.19 (3H, s, CH_3); 7.63 (3H, m, 3,4,5-C_6H_5); 7.88 (2H, dd, J = 8.1, J = 1.3, 2,6-C_6H_5); 8.2 (1H, d, $J_{9,10}$ = 9.5, H-10); 8.24 (1H, d, $J_{4,5}$ = 9.2, H-4); 8.60 (1H, d, $J_{4,5}$ = 9.2, H-5); 8.76 (1H, d, $J_{9,10}$ = 9.5, H-9); 9.69 (1H, s, H-8). Found, %: C 81.44; H 4.38; N 14.18. $C_{20}H_{13}N_3$. Calculated, %: C 81.34; H 4.44; N 14.23.

2,6-Diphenyl-1,3,7-triazapyrene (9c). Yield 0.264 g (74%); mp 197-199ºC (nonane). ^{1}H NMR spectrum, δ, ppm (J, Hz): 7.63 (6H, m, 3,4,5-(2)C_6H_5, 3,4,5-(6)C_6H_5); 7.90 (2H, dd, J = 8.1, J = 1.6, 2,6-(6)C_6H_5); 8.30 (1H, d, $J_{9,10}$ = 9.5, H-10); 8.35 (2H, d, $J_{4,5}$ = 9.2, H-4); 8.63 (1H, d, $J_{4,5}$ = 9.2, H-5); 8.76 (1H, d, $J_{9,10}$ = 9.5, H-9); 8.84 (2H, dd, J = 8.1, J = 1.6, 2,6-(2)C_6H_5); 9.68 (1H, s, H-8). Found, %: C 84.14; H 4.19; N 11.67. $C_{25}H_{15}N_3$. Calculated, %: C 84.01; H 4.23; N 11.76.

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