

A. Messmer\*, Gy. Hajós, J. Giber and S. Holly

Central Research Institute for Chemistry, Hungarian Academy of Sciences,  
H-1825 Budapest, P. O. Box 17, Hungary

Received June 20, 1986

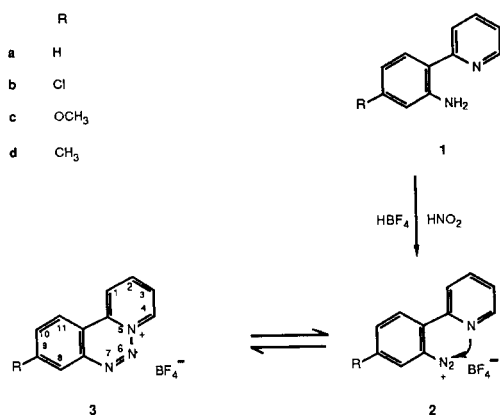
$\alpha$ -Pyridylphenyl diazonium salts **2** were found to undergo valence bond isomerization and gave the new pyrido[1,2-*c*]benzo-*v*-triazinium salts **3**. The ir and nmr studies on the products showed that isomers **2** and **3** form an equilibrium, and the ring closure is favoured by electron withdrawing substituents.

*J. Heterocyclic Chem.*, **24**, 1133 (1987).

Valence bond isomerizations involving closure of five membered heterocycles are reviewed in details in the literature [1] and have also been studied by us [2], while only few cases for valence bond tautomerism resulting in a six membered ring are known [3].

The recognition that  $\alpha$ -pyridylphenyldiazonium salt **2** might undergo valence bond isomerization (internal nucleophilic addition as shown by the arrow) prompted us to study the possibility of formation of the fused *v*-triazinium salt **3**. Interestingly, amine compound **1** as well as its diazotation have already been published earlier [4,5], but no comment has been made by these authors on the ring closure reaction proposed here by us.

Scheme 1



We found that reaction of amine derivative **1a** (prepared by a procedure published by Haworth *et al.* [4]) with nitrous acid followed by treatment of the mixture with aqueous fluoroboric acid resulted in separation of crystals which were collected after a period of 3 days. Elementary analyses and ir spectrum (lack of the  $\nu$ -N $\equiv$ N<sup>+</sup> absorption in the region of 2100-2300 cm<sup>-1</sup>) revealed the formation of the expected new heteroaromatic system: pyrido[1,2-*c*]benzo-*v*-triazinium fluoroborate (**3a**). Appearance of a relatively intense peak at 3120 cm<sup>-1</sup> in ir assigned to the C-H stretching adjacent to the positively charged nitrogen was also found to be in agreement with the proposed structure.

Extraction of the mother liquor by nitromethane resulted in a different crystalline product which showed however, an intense absorption at 2270 cm<sup>-1</sup> in the ir spectrum. Since both analytical data and ir spectra of solutions of the former product **3a** and this new crystalline compound proved to be identical, this latter obtained by extraction was considered as diazonium salt **2a** (the valence bond tautomer of **3a**). Solutions of both products **2a** and **3a** when reacted with  $\beta$ -naphthol gave the same azo compound; a finding which strongly reveals the presence of the diazonium salt **2a** also in solutions of the triazinium isomer **3a**.

In order to prove the existence of an equilibrium between **2** and **3** as well as to investigate the substituent effect, differently substituted derivatives **2,3 b-d** were prepared and their ir spectra were investigated both in the solid state and in solution. These compounds were synthesized in a similar manner to the unsubstituted derivative [4] without any significant modification.

Results of the ir study are shown in Table 1. The presence of the diazonium isomer **2** was detected by the band at 2270 cm<sup>-1</sup>, whereas the triazinium isomer **3** was observed by appearance of the absorption at 3120 cm<sup>-1</sup>. The isomeric ratios were estimated by measurement of extinctions of these bands.

Table I

Investigation of the Equilibrium Between 2-Pyridyl-4-*R*-phenyldiazonium Fluoroborate (**2**) and 9-*R*-Pyrido[1,2-*c*]benzo-*v*-triazinium Fluoroborate (**3**) by IR Spectroscopy

R	Solid phase (KBr)	H <sub>2</sub> O	DMSO	(CF <sub>3</sub> ) <sub>2</sub> CHOH	MeOH	CH <sub>3</sub> CN
H	$\infty$	<1	<1	<1	<1	<1
Cl	[a]	$\infty$	$\gg$ 1	>1	>1	>1
OCH <sub>3</sub>	$\infty$	$\infty$	$\infty$	$\gg$ 1	$\gg$ 1	$\gg$ 1

Equilibrium constants were estimated on the basis of integrals of the peak at 2270 cm<sup>-1</sup> (**2**, diazonium) and at 3120 cm<sup>-1</sup> (**3**, ring closed form). The values refer to an equilibrium constant for the ring closure process ( $K = [\text{triazinium form}]/[\text{diazonium form}]$ );  $\infty$  means triazinium form only; <1, >1 and  $\gg$ 1 denote a K value of approximately 0.5, 3 and 10, respectively, whereas [a] stands for the presence of diazonium salt **2**.

Table I shows that the crystalline products are always present in one of the tautomeric forms **2** or **3** while measurements of their solutions indicated, except in a few cases, a mixture of both isomers. Thus, **3a** (R = H) while exclusively existing in the solid phase, its methanolic solution contains a mixture of **2a** and **3a** (in a ratio of approximately 2:1). On evaporation of this solution, crystalline **3a** could be recovered in good yield, which unambiguously proved the existence of the equilibrium between **2a** and **3a**.

Comparison of the equilibrium constants found in different solutions shows that the ring closure to **3** is favoured by electron withdrawing substituents in position 9. This finding may be accounted for the inductive effect of substituent R which enhances the partial positive charge at the diazonium group (*meta* position) and therefore favours ring closure.

As to the effect of substituent R, the same tendencies can be seen with all of the five solvents investigated, whereas the results obtained in the solid phase are different. It is known, however, from other valence bond isomerization equilibria [6] that the energy conditions in the crystalline state can often offset other important factors, e.g. substituent effects.

An interesting and, at first sight, contradictory result was obtained with <sup>1</sup>H-nmr study of these isomeric mixtures. While formation of mixtures of **2a**  $\rightleftharpoons$  **3a** and **2b**  $\rightleftharpoons$  **3b** and an equilibrium strongly shifted to **3c** was found by ir in acetonitrile solutions, the nmr spectra of the same solutions showed only one single component in all the three cases. This phenomenon can be explained by assuming a very rapid equilibrium between **2** and **3**. In this case, the ir can still serve as a suitable method for detection of both isomers, while, under nmr conditions, a mean value of shifts of the two equilibric forms should appear.

Table II

Comparison of the Chemical Shifts Found at the Lowest Field in the <sup>1</sup>H-NMR Spectra of Mixtures Containing the **2** and **3** Isomers

R	ppm
H	8.96
Cl	9.60
OCH <sub>3</sub>	9.63

Deuterioacetonitrile, 25°; shifts assigned to proton H-4 (numbering of the ring closed compound **3**).

Table II containing chemical shifts of H-4 protons (numbering according to the ring closed isomer **3**) reveals satisfactorily the above supposition: in the case of the methoxy derivative (the equilibrium mixture contains predominantly **3c**), the H-4 shift appears at a value lower by 0.6 ppm

than that found with **2a**  $\rightleftharpoons$  **3a** (shifted strongly to the diazonium isomer). In the case of chloro compound (**2b**  $\rightleftharpoons$  **3b**) which shows an equilibrium constant higher than that of **2a**  $\rightleftharpoons$  **3a** approximately by one order of magnitude, the corresponding shift appears between the above extremes, near to that of derivative **c** (R = OCH<sub>3</sub>).

To the best of our knowledge, compound **3** forms the first example for ring system involving heteroaromatic pyrido[1,6-*c*]-*v*-triazine moiety. Further study and extension of this valence bond isomerization is in progress.

## EXPERIMENTAL

The nmr spectra were obtained by a Varian XL-100 equipment. The ir spectra were recorded on a Nicolet 7199 FT-IR spectrometer; the resolution was 4 cm<sup>-1</sup> within the whole range; concentrations between 10<sup>-1</sup> and 10<sup>-2</sup> mole/liter were used; thickness was varied between 0.06 and 0.16 mm. Melting points are uncorrected.

General Procedure for the Preparation of 2-(4-*R*-2-Nitrophenyl)pyridines.

A mixture of 4-*R*-2-nitroaniline (0.23 mole) and concentrated hydrochloric acid (60 ml) was treated with sodium nitrite solution (0.26 mole) at 0-5°, the resulting solution was filtered and the filtrate was added dropwise to pyridine (470 ml) so that the internal temperature did not exceed 40°. The mixture was finally refluxed for 45 minutes, treated with an excess of sodium hydroxide solution and purified by steam distillation. An isomeric mixture of 4-*R*-nitrophenylpyridines was obtained which was first converted to a mixture of picrate salts. Recrystallization of the salt mixture from acetone and treatment of the first crystalline fraction with sodium hydroxide solution afforded the desired crude base.

2-(4-Chloro-2-nitrophenyl)pyridine.

This compound was obtained as a yellow oil, 3.8 g (7%).

*Anal.* Calcd. for C<sub>11</sub>H<sub>7</sub>ClN<sub>2</sub>O<sub>2</sub>: C, 56.31; H, 3.01; N, 11.94. Found: C, 56.18; H, 2.81; N, 11.86.

2-(4-Methoxy-2-nitrophenyl)pyridine.

This compound was obtained as yellow prisms (diethyl ether), mp 23-26° (7%); <sup>1</sup>H-nmr (deuteriochloroform): 8.63 (m, 1H, H-6), 8.05 (d, 1H, H-3), 7.29-7.82 ppm (m, 5H, H-4,5,3',6'), 3.33 (s, 3H, OCH<sub>3</sub>).

*Anal.* Calcd. for C<sub>12</sub>H<sub>10</sub>N<sub>2</sub>O<sub>3</sub>: C, 62.60; H, 4.38; N, 12.17. Found: C, 62.80; H, 4.27; N, 11.95.

2-(4-Methyl-2-nitrophenyl)pyridine.

This compound was obtained as yellow prisms (diethyl ether), 3.5 g (6.3%), mp 57-58°; <sup>1</sup>H-nmr (deuteriochloroform): 8.65 (m, 1H, H-6), 8.02 (d, 1H, H-3), 7.24-7.79 (m, 5H, H-4,5,3',6'), 2.37 ppm (s, 3H, CH<sub>3</sub>).

2-(4-*R*-2-aminophenyl)pyridines (**1**).

Amino compounds **1b-d** were prepared from the above nitro compounds by application of the procedure described by Haworth and Hey [4] (i.e. by treatment of a solution of 3.8 mmoles of nitro compound in 1.6 ml of concentrated hydrochloric acid followed by stirring the mixture for 2 hours).

2-(4-Chloro-2-aminophenyl)pyridine (**1b**).

This compound was obtained as a yellow oil (76%).

*Anal.* Calcd. for C<sub>11</sub>H<sub>7</sub>ClN<sub>2</sub>: C, 64.54; H, 4.43; N, 13.69. Found: C, 64.23; H, 4.67; N, 13.54.

2-(4-Methoxy-2-aminophenyl)pyridine (**1c**).

This compound was obtained as a yellow oil (82%).

*Anal.* Calcd. for C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>O: C, 71.98; H, 6.04; N, 13.99. Found: C, 71.82; H, 6.00; N, 13.71.

2-(4-Methyl-2-aminophenyl)pyridine (**1d**).

This compound was obtained as colorless prisms, (42%) mp 103-105° (pyridine).

*Anal.* Calcd. for C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>: C, 78.23; H, 6.57; N, 15.21. Found: C, 77.95; H, 6.32; N, 15.34.

9-*R*-Pyrido[1,2-*c*]benzo-*v*-triazinium Fluoroborates **3** and their Diazonium Isomer **2**.

A mixture of 2-(2-aminophenyl)pyridine (**1a**) (5.0 g, 29.3 mmoles) and concentrated hydrochloric acid (33 ml) was stirred at 5° and treated with an aqueous solution of sodium nitrite (2.5 g) at this temperature. After addition of the reagent, 35 percent fluoroboric acid (8.8 g) was added and the mixture was stored at -10° for 3 days. Colorless crystals separated which were filtered and washed with water to give 1.7 g (21%) of product; <sup>1</sup>H-nmr (deuterioacetonitrile): δ 8.96 (m, 1H, H-7), 8.64 (m, 1H, H-11), 8.52 (m, 1H, H-3), 8.42-8.24 (m, 3H, H-2, 9, 10), 8.02 (m, 1H, H-1), 7.77 ppm (m, 1H, H-8).

*Anal.* Calcd. for C<sub>11</sub>H<sub>8</sub>BF<sub>4</sub>N<sub>3</sub>: C, 49.11; H, 3.00; N, 15.62. Found: C, 49.05; H, 2.92; N, 15.23.

The mother liquor was extracted with nitromethane (3 × 10 ml), and evaporation of the organic layer yielded 1.2 g (15%) of **2a** as a novel crystalline product, mp 102-104°; <sup>1</sup>H-nmr and ir spectra of the solutions of this product were found to be identical with those of compound **3a**; ir (potassium bromide): strong absorption at 2270 cm<sup>-1</sup>, no peak at 3120 cm<sup>-1</sup>.

By the above procedure, the following derivatives were obtained:

2-(2-Pyridyl)-4-chlorophenyldiazonium Fluoroborate (**2b**).

This compound was obtained as colorless crystals, mp 137-138°, 37%; <sup>1</sup>H-nmr (deuterioacetonitrile): δ 9.60 (m, 1H, H-7), 8.96 (m, 1H, H-10), 8.8 (m, 1H, H-11), 8.76 (m, 2H, H-9,3), 8.34-8.18 ppm (m, 2H, H-1,8).

*Anal.* Calcd. for C<sub>11</sub>H<sub>7</sub>BClF<sub>4</sub>N<sub>3</sub>: C, 43.54; H, 2.33; N, 13.85. Found: C, 43.20; H, 2.15; N, 13.57.

9-Methoxybenzo[e]pyrido[1,6-*c*]-*v*-triazinium Fluoroborate (**3c**).

This compound was obtained as colorless crystals, mp 122-123°, 45%; <sup>1</sup>H-nmr (deuterioacetonitrile): δ 9.63 (m, 1H, H-7), 8.94 (m, 1H, H-10), 8.79 (m, 1H, H-11), 8.74 (m, 2H, H-9,3), 8.38-8.24 (m, 2H, H-1,8), 3.32 ppm

(s, 3H, OCH<sub>3</sub>).

*Anal.* Calcd. for C<sub>12</sub>H<sub>11</sub>BF<sub>4</sub>N<sub>3</sub>O: C, 48.03; H, 3.70; N, 14.01. Found: C, 48.00; H, 3.62; N, 13.95.

9-Methylbenzo[e]pyrido[1,6-*c*]-*v*-triazinium Fluoroborate (**3d**).

This compound was obtained as colorless crystals, mp 103-105°, 33%.

*Anal.* Calcd. for C<sub>12</sub>H<sub>11</sub>BF<sub>4</sub>N<sub>3</sub>: C, 50.74; H, 3.90; N, 14.79. Found: C, 50.36; H, 3.74; N, 14.43.

Reaction of **2a** or **3a** with β-Naphthol.

A mixture of **2a** or **3a** (269 mg, 1.0 mmole) and 0.8 ml of 5% sodium hydroxide solution was treated with a solution of β-naphthol (144 mg, 1.0 mmoles) in 0.2 ml of 5% sodium hydroxide solution, whereupon red crystals precipitated immediately, 380 mg (86%), mp 188-190°; <sup>1</sup>H-nmr (deuteriochloroform): δ 9.05 (m, 1H, H-α-pyridyl), 8.6-8.4 (m, 2H, H-β,γ-pyridyl), 7.9-7.2 (m, 10H, H-aryl), 6.65 ppm (d, 1H, H-3-naphthyl); uv (ethanol): 438, 302 nm.

*Anal.* Calcd. for C<sub>21</sub>H<sub>15</sub>N<sub>3</sub>O (325.38): C, 77.52; H, 4.65; N, 12.92. Found: C, 77.28; H, 4.92; N, 12.70.

Acknowledgement.

Thanks are due to Dr. L. Radics for the nmr spectra and the valuable discussions.

## REFERENCES AND NOTES

- [1] E. C. Taylor and I. J. Turchi, *Chem. Rev.*, **79**, 181 (1979).
- [2] A. Messmer, Gy. Hajós, P. Benkó and L. Pallos, *J. Heterocyclic Chem.*, **10**, 575 (1973).
- [3a] A. W. Murray and K. Vanghan, *J. Chem. Soc., Chem. Commun.*, 1972 (1967); [b] M. F. G. Stevens, *J. Chem. Soc. (C)*, 1096 (1967); [c] S. M. Mackensie and M. F. G. Stevens, *J. Chem. Soc. (C)*, 2298 (1970); [d] D. Harrison and A. C. B. Smith, *J. Chem. Soc.*, 2157 (1960).
- [4] J. W. Haworth and D. H. Hey, *J. Chem. Soc.*, 349 (1940).
- [5] R. R. Schmidt, *Tetrahedron Letters*, 1925 (1971).
- [6] M. Tisler, *Synthesis*, 123 (1973).