

Different Reactivities of 1- and 3-Olates with Electrophiles [1]

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A novel convenient synthesis of the title system has been developed using α -carbonyl derivatives of *N*-aminopyridine and formamide (and its substituted derivatives) in the presence of phosphorus oxychloride or boron trifluoride. Quaternization of zwitterionic 1- and 3-olates (4a, 4b; 11) with soft and hard methylating agents has been studied. Mechanistic suggestion are given to explain the formation of the different (solely N-Me; N-Me and O-Me; solely OMe) products.

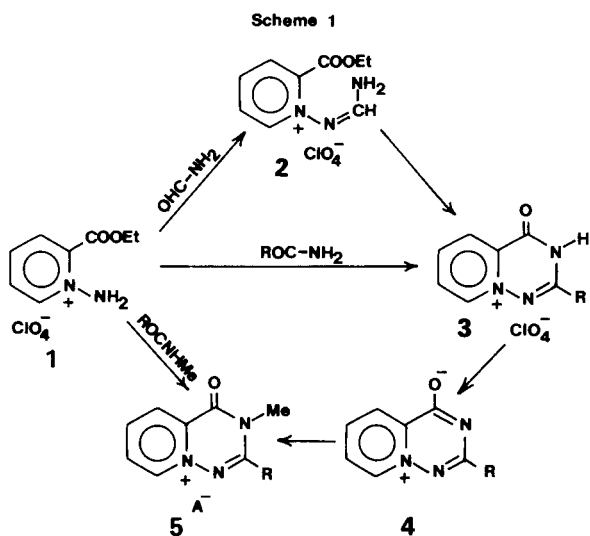
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In the course of our investigations [2] concerning the synthesis of fused *as*-triazines we wished to prepare bridgehead nitrogen containing systems. Among these four, theoretically possible, positively charged pyrido-*as*-triazinium salts we now describe a novel and convenient synthesis of pyrido[2,1-*f*]-*as*-triazinium salts and their zwitterionic derivatives.

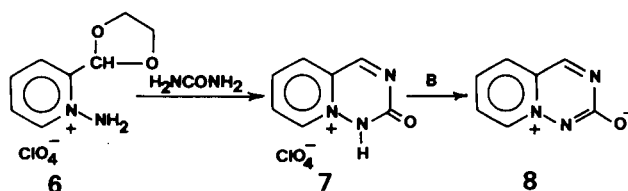
The first representatives of the pyrido[2,1-*f*]-*as*-triazinium system have been reported by Neunhoeffer *et al.* [3] and Kakehi *et al.* [4]. Most recently, Katritzky *et al.* [5,6] then Molina *et al.* [7] have published the formation of diarylpyrido[2,1-*f*]-*as*-triazinium salts *via* ring transformation of diarylpyridinium salts with hydrazines.

We wanted to realize the preparation of the title compound by analogy to Niementowski's quinazolone synthesis [8,9]. For this purpose, first of all, we have investigated the reaction of picolinic acid ethyl ester *N*-aminium salts with formamide and its derivatives.

We have found that *N*-aminium perchlorate **1** was readily formed by transformation of the appropriate tosylate salt which, in turn, was produced in the reaction of picolinic acid ethyl ester with TSH [10] in 90% yield.



Scheme 2



According to expectations, **1** reacts with formamide at 100° in the presence of phosphorus oxychloride, affording the cyclized 1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium perchlorate **3** in a yield of about 80%. It was possible to isolate the acyclic intermediate 1-formamido-2-ethoxycarbonylpyridinium perchlorate **2** when the reaction was carried out at room temperature for a shorter time. Heating **2** to 120°, **3** was obtained again; this fact showed that the condensation of the N-NH₂ group of **1** with the carbonyl moiety of formamide was the first step of ring closure. The cyclic structure of **3**, related to **1** and **2**, supported by the disappearance of the ir band of the amidine group (no band at 1680 cm⁻¹), and by the bathochromic shift (330 nm instead of 300 nm, in ethanol) in the uv spectra.

Table I

Characteristics of 1(2*H*)-Oxopyrido[2,1-*f*]-*as*-triazinium Perchlorates

Compound	R ¹	R ²	Mp (°C)	Yield (%)
3a	H	H	243-244	76
3b	Ph	H	281-283	22 [1], 44 [2]
3c	4-Cl-C ₆ H ₄	H	276-279	59 [2]
5a	H	Me	284-286	71
5b	Ph	Me	326-328	77
5c	Me	Me	270-271	67

[1] Procedure A: Benzamide was used as reagent. [2] Procedure B: Instead of benzamide, benzonitrile and 4-chlorobenzonitrile have been used, respectively.

The ring closure reaction with formamide could be extended to other acid amides and *N*-Me acid amides. Our synthesis - which can be regarded as the first generalization of Niementowski's synthesis to *N*-aminohetaryl compounds - resulted in 1-(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium salts (Table I). When reacted with base, these compounds can be easily transformed into the remarkably stable zwitterionic pyrido[2,1-*f*]-*as*-triazin-5-ium-1-olates (**4a**, **b**, **c** in Table II). The zwitterionic structure of compounds **4** is supported, *inter alia*, by the observation of significant solvatochromic effect in their uv and visible spectra.

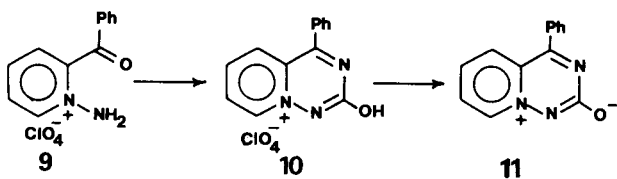
Table II

Characteristics of Zwitterionic Pyrido[2,1-*f*]-*as*-triazin-5-ium-1-olates

4	R	Mp (°C)	Yield (%)
a	H	237-238	71
b	Ph	224-227	59
c	4-Cl-C ₆ H ₄	283-285	62

For producing 3-oxo derivatives **7** in addition to 1-oxo compounds **3** a further variation of the synthesis - the reaction of pyridine-2-aldehyde *N*-aminium salt with urea - has been tried. It turned out, however, that already the *N*-amination of pyridine-2-aldehyde led to a multicomponent mixture, *i.e.* protection of the aldehyde group is required. The reaction of 2-(1,3-dioxolan-2-yl)pyridine [11] with TSH gave the appropriate *N*-aminium salt **6** in excellent (87%) yield. This latter compound **6** was allowed to react with urea in the presence of boron trifluoride-acetic acid, resulting in 3-(4*H*)-oxopyrido[2,1-*f*]-*as*-triazinium perchlorate (**7**) in about 50% yield.

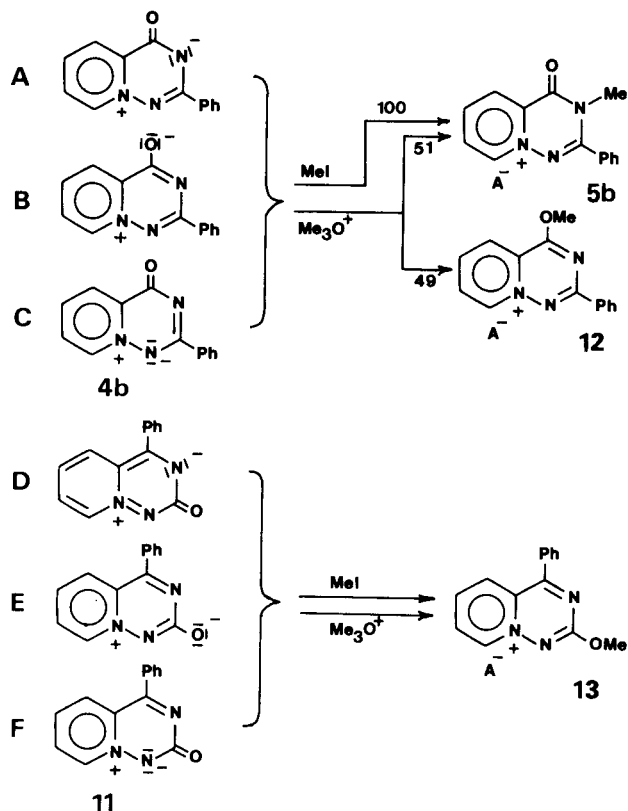
Scheme 3



The reaction of 1-amino-2-benzoylpyridinium perchlorate **9** (received by direct *N*-amination of unprotected 2-benzoylpyridine [10]) with urea in polyphosphorus acid afforded 3-hydroxy-1-phenylpyrido[2,1-*f*]-*as*-triazinium perchlorate **10**. Treatment of this salt **10** with base led again to a stable zwitterion *viz.* 1-phenylpyrido[2,1-*f*]-*as*-triazin-5-ium-3-olate **11** in 64% yield.

For a comparative investigation on the nucleophilic reactivity of zwitterionic compounds, the phenyl substituted, stable 3-phenyl-1-olate **4b** and 1-phenyl-3-olate **11** seemed to be more suitable substrates than the unsubstituted pair of 1- and 3-olates **4a**, **8** because of the thermal instability of the latter compound.

Scheme 4



Protonation, *i.e.* treatment of zwitterionic compounds with strong acids resulted in the appropriate salts immediately. Thus, both types of olates **4b** and **11** reacted with perchloric acid affording the parent perchlorate salts **3** and **10** in almost quantitative yield. Significant differences in products have been observed, however, during the similarly electrophilic methylation process.

We have found that the methylation of the unsubstituted 1-olate **4a** resulted exclusively in 2-methyl-1-(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium salts **5a** in almost quantitative yield, regardless of the soft or hard nature [12,13] of the

Table III

Methylation of Pyrido[2,1-*f*]-*as*-triazinium-1-olates (**4a**, **4b**) and 3-olate (**11**) with Soft and Hard Reagents

Substratum	Electrophile	Product	Yield	Mp (°C)
4a	MeI	5a , A = I	99	273-275
	Me ₂ SO ₄	5a , A = MeSO ₄	95	190-191
	MeOTs	5a , A = TsO	97	215-217
	Me ₃ O ⁺ PF ₆ ⁻	5a , A = PF ₆	92	173-176
4b	MeI	5b , A = I	88	288-290
	Me ₃ O ⁺ PF ₆ ⁻	5b + 12 (1:1) A = PF ₆	100	278-286
11	MeI	13 , A = I	60	260-263
	Me ₃ O ⁺ PF ₆ ⁻	13 , A = PF ₆	97	209-211

reagents used (see Table III). The structure of compound **5a** has been proved unambiguously by a cross-synthesis. The cyclization reaction of **1** performed with *N*-methylformamide led to 2-*N*-Me (and certainly not to 4-*N*-Me) **5a** (80%), which was identical to the product of methylation of **4a**.

The methylation of 3-phenylpyrido[2,1-*f*]-*as*-triazinium-1-olate **4b** resulted in different products when the soft reagent used was changed to a hard one. Thus, the reaction of **4b** with methyl iodide afforded exclusively *N*-Me product (**5b**, A = I) *viz.* 2-methyl-3-phenyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium iodide; the methylation of **4b** with trimethyloxonium hexafluorophosphate, however, gave *N*-Me and OMe products in a ratio of 1:1 (almost equal intensities of two methyl singlets in ¹H-nmr spectrum, DMSO-*d*₆). In this latter reaction 1-methoxy-3-phenylpyrido[2,1-*f*]-*as*-triazinium salts (**12**, A = PF₆) was formed in addition to the *N*-Me (**5b**, A = PF₆) compound.

In contrast to the ambident reactivity of **4b**, the reaction of 1-phenylpyrido[2,1-*f*]-*as*-triazinium-3-olate **11** both with methyl iodide and with trimethyloxonium hexafluorophosphate led to the formation of salts of the same cation which proved to be an OMe derivative, *viz.* 3-methoxy-1-phenylpyrido[2,1-*f*]-*as*-triazinium salt (**13**, A = I and A = PF₆, respectively).

On the basis of the different results of the methylation of zwitterionic 1- and 3-olates (**4a**, **4b** and **11**) with various kinds of reagents the following conclusions could be drawn. The points of attack of the electrophilic methylating reagents are controlled - in addition to the nature of the reagent - by the availability of lone pairs of electrons of the heteroatoms of zwitterions which, in turn, depends mostly (i) on the electronegativity of the atom in question, (ii) on the partial negative charge, and (iii) on the steric hindrance at this site.

Because of the smaller electronegativity of nitrogen as compared with oxygen, the expected order of preferred points of attack is N-2 > O ≫ N-4. The availability of the lone pair at N-4 is strongly decreased by influence of the positive charge of the neighbouring bridgehead *N*-atom. In the case of the unsubstituted 1-olate **4a** methylation occurs both with soft and with hard reagents at N-2, showing that the effect of the somewhat greater negative charge of O is overbalanced when N-2 is not hindered sterically.

The comparison of reactivity of 3-phenyl-1-olate **4b** and 1-phenyl-3-olate **11** derivatives is facilitated by the consideration of zwitterionic resonance hybrid structures **A-F**.

In the case of 3-phenyl-1-olate **4b**, the accessibility of the lone pair at N-2 (**A**) is somewhat hindered by the presence of the phenyl group at C-3 and therefore the greater partial negative charge of O is felt: The uncharged reagent (MeI) attacks only at N-2, the charged reagent (Me₃O⁺), however, attacks both at the O (**B**) and N-2 (**A**) atoms.

Successful attacks at N-4 (**C** in **4b** and **F** in **11**) are excluded because of the neighbouring positive charge.

In the case of 1-phenyl-3-olate **11**, the availability of the lone pair at N-2 (**D**) is, however, hindered not only sterically but also by the loss of resonance stabilization. There is no circle, *i.e.* aromatic sextet in pyridine moiety in structure **D** and the requirement of extended Clar's rule [14, 16] is not met. Thus, **E** remains the only relatively stable reactive structure and, as a consequence, only OMe **13** product is formed, regardless of the nature of reagents used. Work on further study concerning synthesis and methylation of fused heteroaromatic zwitterions is in progress.

EXPERIMENTAL

Melting points were determined on a Büchi capillary melting point apparatus and are uncorrected. The ir spectra were recorded using a Specord 75 IR apparatus. The nmr spectra were determined on a Varian EM 360-A spectrometer using TMS as an internal standard. The uv spectra were obtained on a Unicam SP 800-B equipment.

1-(*N*-Formamidino)-2-ethoxycarbonylpyridinium Perchlorate (**2**).

A solution of 0.27 g (1 mmole) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) in 0.4 ml of formamide was stirred with 0.4 ml of phosphorus oxychloride for 30 minutes at 60°. The reaction mixture was dissolved in 5 ml of water, and extracted with 3 × 5 ml of nitromethane. The organic solution was dried over anhydrous magnesium sulphate, filtered and evaporated *in vacuo*. The residue was triturated with 1 ml of ethanol to give 0.15 g (52%) of crude product which was recrystallized from ethanolether to provide 0.11 g (38%) of colorless needles, mp 114-117° (melts under sparking, then solidifies and melts again at 242-244°); ir (potassium bromide): 3100, 3010, 2910, 2850, 1730, 1680, 1630, 1560, 1450, 1290 cm⁻¹.

Anal. Calcd. for C₁₅H₁₂ClN₃O₆: C, 38.81; H, 4.12; N, 14.31; Cl, 12.07. Found: C, 38.66; H, 4.17; N, 14.10; Cl, 12.12.

1-(2*H*)-Oxopyrido[2,1-*f*]-*as*-triazinium Perchlorate (**3a**).

Into a stirred solution of 22 g (82.5 mmole) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) in 32 ml of formamide, 32 ml of phosphorus oxychloride was dropped at 100°. **Caution!** The reaction is strongly exothermic and a large amount of hydrogen cyanide is evolved which was introduced to an alkaline permanganate solution. The mixture was stirred at 100° for an hour then cooled and dissolved in 100 ml of water. The solution was saturated with sodium perchlorate and extracted with 4 × 100 ml of nitromethane. The extract was dried and evaporated *in vacuo* and the crystalline crude product was recrystallized from 150 ml of 75% ethanol to give 15.5 g (76%) of colorless prisms, mp 243-244°; ir (potassium bromide): 3000, 2700, 2600, 1735, 1715, 1625, 1560, 1480, 1450, 1100 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 9.33 (dd, 1H, H-6), 8.82 (1H, H-9), 8.76 (m, 1H, H-8), 8.7 (s, 1H, H-3), 8.46 (m, 1H, H-7); uv (96% ethanol): λ max 323, 256, 225 nm, infl: 330, 300 nm.

Anal. Calcd. for C₈H₆ClN₃O₃: C, 33.96; H, 2.44; N, 16.97; Cl, 14.32. Found: C, 34.04; H, 2.55; N, 16.78; Cl, 14.11.

Pyrido[2,1-*f*]-*as*-triazin-5-ium-1-olate (**4a**).

A solution of 205 mg (0.83 mmole) of 1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium perchlorate (**3a**) in 10 ml of acetonitrile was stirred with a solution of 46.5 mg (0.83 mmole) of potassium hydroxide in 1 ml of ethanol. The reaction mixture was filtered, evaporated and the residue was recrystallized from 10 ml of acetonitrile to give 87 mg (71%) of white crystals, mp 237-238°; ir (potassium bromide): 3000, 1640, 1620, 1520, 1480, 1450 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 9.02 (dd, 1H, H-6), 8.57 (dd, 1H, H-9), 8.45 (s, 1H, H-3), 8.42 (m, 1H, H-8), 8.15 (m, 1H, H-7); uv (96% ethanol): λ max

328, 255, 247, 241 nm; (significant negative solvatochrom effect in different solvents: first λ max (nm) in water 314; ethanol 328; acetonitrile 336; chloroform 343; carbon tetrachloride 353).

Anal. Calcd. for $C_7H_5N_3O$: C, 57.14; H, 3.43; N, 28.56. Found: C, 56.86; H, 3.58; N, 28.32.

2-Methyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Iodide (**5a**, A = I).

A suspension of 0.2 g (1.36 mmoles) of pyrido[2,1-*f*]-*as*-triazinium-1-olate (**4a**) in 2 ml of acetonitrile was stirred with 0.42 ml (0.96 g, 6.8 mmoles) of methyl iodide at 25° for 24 hours. The precipitated yellow crystals were filtered and washed with ether to give 0.39 g (99%) of analytically pure product, mp 273-275°; ir (potassium bromide): 3000, 2950, 2900, 1710, 1630, 1560, 1480, 1450 cm^{-1} ; ¹H-nmr (DMSO-*d*₆): δ 9.55 (dd, 1H, H-6), 9.24 (s, 1H, H-3), 8.95 (m, 2H, H-8,9), 8.62 (m, 1H, H-7), 3.66 (s, 3H, CH₃); uv (water): λ max 300, 243, 227 nm, infl: 313, 290, 234 nm.

Anal. Calcd. for $C_8H_8IN_3O$: C, 33.24; H, 2.79; N, 14.54; I, 43.90. Found: C, 33.39; H, 2.83; N, 14.62; I, 43.59.

The perchlorate salt prepared from the iodide salt had the same mp, ir, ¹H-nmr, and uv as 2-methyl product **5a**, obtained directly from 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) with *N*-methylformamide.

2-Methyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Tosylate (**5a**, A = TsO).

A suspension of 0.15 g (1 mmole) of pyrido[2,1-*f*]-*as*-triazinium-1-olate (**4a**) in 2 ml of acetonitrile was stirred with 0.94 g (5 mmoles) of methyltosylate for 2 days at 25°. The precipitate was filtered to give 0.32 g (97%) of pure product, mp 215-217°. This compound was converted into perchlorate salt, having the same mp, ir, ¹H-nmr and uv as 2-methyl product **5a**, obtained with *N*-methylformamide from **1**.

2-Methyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Hexafluorophosphate (**5a**, A = PF₆).

A suspension of 0.15 g (1 mmole) of pyrido[2,1-*f*]-*as*-triazinium-1-olate (**4a**) in 5 ml of chloroform was stirred with 0.21 g (1 mmole) of trimethylxonium hexafluorophosphate at 25° for 20 hours. The reaction mixture was mixed with 15 ml of ether and filtered to give 0.33 g (92%) of product, mp 173-176°. The product was converted into perchlorate salt which had the same mp, ir, ¹H-nmr and uv as 2-methyl compound **5a**, obtained with *N*-methylformamide from **1**.

2-Methyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Methylsulfate (**5a**, A = MeSO₃).

A suspension of 0.2 g (1.36 mmoles) of pyrido[2,1-*f*]-*as*-triazinium-1-olate (**4a**) in 2 ml of acetonitrile was stirred at 25° with 0.85 g (0.64 ml, 6.8 mmoles) of dimethylsulfate for 24 hours. The reaction mixture was filtered and the crude product was recrystallized from acetonitrile to give 0.33 g (89%) of white needles, mp 190-191°. The product was converted into perchlorate salt which had the same mp, ir, ¹H-nmr and uv as the 2-methyl salt (**5a**), obtained with *N*-methylformamide from **1**.

2-Methyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Perchlorate (**5a**).

A solution of 1.3 g (4.9 mmoles) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) in 3 ml of *N*-methylformamide was stirred with 2 ml of phosphorus oxychloride at 80° for an hour. The reaction mixture was cooled and poured onto ice/water saturated with sodium perchlorate. The precipitate was filtered and recrystallized from aqueous ethanol to give 0.9 g (71%) of white needles, mp 284-286°; ir (potassium bromide): 3010, 3000, 2890, 1715, 1630, 1565, 1480, 1440, 1100 cm^{-1} ; ¹H-nmr (DMSO-*d*₆): δ 9.52 (m, 1H, H-6), 9.14 (s, 1H, H-3), 8.9 (m, 2H, H-8,9), 8.56 (m, 1H, H-7), 3.6 (s, 3H, CH₃); uv (ethanol): λ max 302, 243, 237, 228 nm, infl: 315, 290 nm.

Anal. Calcd. for $C_8H_8ClN_3O_5$: C, 36.73; H, 3.08; N, 16.06; Cl, 13.55. Found: C, 36.52; H, 3.21; N, 15.87; Cl, 13.72.

2,3-Dimethyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Perchlorate (**5c**).

A solution of 12 g (45 mmoles) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) in 25 ml of *N*-methylacetamide was stirred with 20 ml of phosphorus oxychloride at 90° for an hour. The reaction mixture was

cooled, poured onto ice/water saturated with sodium perchlorate. The precipitate was filtered and recrystallized from aqueous ethanol to give 8.3 g (67%) of white needles, mp 270-271°; ir (potassium bromide): 3040, 2900, 1700, 1620, 1570, 1495, 1430, 1100 cm^{-1} ; uv (ethanol): λ max 306, 245, 237, 229 nm.

Anal. Calcd. for $C_{10}H_{10}ClN_3O_5$: C, 39.21; H, 3.66; N, 15.24. Found: C, 38.95; H, 3.84; N, 15.22.

3-Phenyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Perchlorate (**3b**). Procedure A.

A mixture of 5.4 g (20 mmoles) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) and 24.2 g (200 mmoles) of benzamide was stirred in 15 ml of phosphorus oxychloride at 80° for 2 hours. The reaction mixture was cooled and poured onto 100 ml of ice/water. Water and benzonitrile were evaporated, the residue was suspended in 50 ml of saturated sodium perchlorate solution in water and extracted with nitromethane (4 × 60 ml). The nitromethane solution was dried over anhydrous magnesium sulfate filtered and evaporated *in vacuo*. The residue was recrystallized from aqueous ethanol to give 1.15 g (18%) of white needles (1.1 g of starting salt **1** can be obtained from the mother liqueur, in this respect the yield of **3b** was 22%), mp 281-283°; ir (potassium bromide): 3120, 3050, 1740, 1620, 1570, 1510, 1470, 1450, 1100 cm^{-1} ; ¹H-nmr (DMSO-*d*₆): δ 9.60 (dd, 1H, H-6), 8.9-8.5 (m, 3H, H-7,8,9), 8.25-7.8 (m, 5H, phenyl), 6.10 (s, 1H, NH); uv (ethanol): λ max 340, 257, infl: 280 nm.

Anal. Calcd. for $C_{13}H_{10}ClN_3O_5$: C, 48.24; H, 3.11; N, 12.98. Found: C, 48.62; H, 3.15; N, 12.90.

Procedure B.

To a stirred suspension of 8.0 g (30 mmoles) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) in 30 ml of benzonitrile, 3.03 g (4.2 ml, 30 mmoles) of triethylamine was dropped very slowly at 100° (30 minutes). The reaction mixture was stirred at 100° for 10 minutes, then cooled and mixed with 2.6 ml of 70% perchloric acid and 70 ml of ether. The precipitate was filtered and recrystallized from aqueous ethanol to give 4.3 g (44%) of white needles with the same mp, ir, ¹H-nmr and uv as above.

3-(4-Chlorophenyl)-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Perchlorate (**3c**).

Eight g (30 mmoles) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) and 41.3 g (300 mmoles) of 4-chlorobenzonitrile were reacted according to procedure B to give 6.3 g (59%) of white needles, mp 276-280°; ir (potassium bromide): 3110, 3080, 2700, 1720, 1600, 1570, 1500, 1470, 1440, 1100 cm^{-1} ; ¹H-nmr (DMSO-*d*₆): δ 9.42 (dd, 1H, H-6), 8.9-8.1 (m, 5H, H-7,8,9 and 3',5'), 7.70 (m, 3H, H-2',6' and NH).

Anal. Calcd. for $C_{13}H_9Cl_2N_3O_5$: C, 43.60; H, 2.53; N, 11.73. Found: C, 43.89; H, 2.84; N, 11.62.

3-Phenylpyrido[2,1-*f*]-*as*-triazin-5-ium-1-olate (**4b**).

A solution of 0.64 g (2 mmoles) of 3-phenyl-1(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium perchlorate (**3b**) in 15 ml of ethanol was stirred at 25° with a solution of 0.11 g (2 mmoles) of potassium hydroxide in 5 ml of ethanol for 30 minutes. The reaction mixture was filtered and evaporated to dryness *in vacuo* and the residue was recrystallized from water to give 0.26 g (59%) of pale yellow crystals, mp 224-227°; ir (potassium bromide): 3120, 3080, 3070, 3040, 1645, 1630, 1600, 1580, 1510, 1460, 1440, 1420, 1400, 1280 cm^{-1} ; ¹H-nmr (DMSO-*d*₆): δ 9.10 (dd, 1H, H-6), 8.7-7.4 (m, 8H, H-7,8,9 and phenyl); uv (ethanol): λ max 344, 332, 252 nm.

Anal. Calcd. for $C_{13}H_9N_3O$: C, 69.94; H, 4.06; N, 18.82. Found: C, 69.58; H, 4.15; N, 19.03.

3-(4-Chlorophenyl)pyrido[2,1-*f*]-*as*-triazin-5-ium-1-olate (**4c**).

A mixture of 0.72 g (2 mmoles) of 3-(4-chlorophenyl)pyrido[2,1-*f*]-*as*-triazinium perchlorate and 0.11 g (2 mmoles) of potassium hydroxide was reacted as above to give 0.32 g (62%) of product, mp 283-285°; ir (potassium bromide): 3120, 3060, 3030, 1640, 1605, 1590, 1575, 1500, 1430, 1400 cm^{-1} ; ¹H-nmr (DMSO-*d*₆): δ 9.21 (dd, 1H, H-6), 8.7-8.1 (m, 5H, H-7,8,9 and 3',5'), 7.60 (m, 2H, H-2',6').

Anal. Calcd. for $C_{13}H_8ClN_3O$: C, 60.59; H, 3.13; N, 16.31. Found: C, 60.32; H, 3.41; N, 16.25.

2-Methyl-3-phenyl-1-(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Iodide (**5b**, A = I).

A suspension of 0.11 g (0.5 mmole) of 3-phenylpyrido[2,1-*f*]-*as*-triazinium-1-olate (**4b**) in 1 ml of acetonitrile was stirred at 25° with 0.2 ml (0.43 g, 3.2 mmoles) of methyl iodide for 24 hours. The precipitate was filtered and washed with ether to give 0.16 g (88%) of product, mp 288-290°; ir (potassium bromide): 3060, 2950, 1710, 1610, 1600, 1560, 1480, 1420, 1375 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 9.51 (dd, 1H, H-6), 9.1-8.1 (m, 3H, H-7,8,9), 7.80 (m, 5H, phenyl), 3.49 (s, 3H, CH₃); uv (ethanol): λ max 311, 244, 237 nm.

Anal. Calcd. for C₁₄H₁₂IN₃O: C, 46.05; H, 3.31; N, 11.51. Found: C, 45.72; H, 3.46; N, 11.46.

The product was converted into perchlorate salt having the same mp, ir, ¹H-nmr and uv as 2-methyl derivative **5b**, obtained directly from **1** with *N*-methylbenzamide.

2-Methyl-3-phenyl-1-(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium Perchlorate (**5b**).

A mixture of 2.7 g (10 mmoles) of 1-amino-2-ethoxycarbonylpyridinium perchlorate (**1**) and 2.8 g (20 mmoles) of *N*-methylbenzamide was stirred at 80° with 6 ml of phosphorus oxychloride for an hour. The reaction mixture was poured onto 50 ml of ice/water saturated with sodium perchlorate. The precipitate was filtered, washed with water and recrystallized from 50% ethanol to give 2.6 g (77%) of pale yellow needles, mp 326-328°; ir (potassium bromide): 3120, 3100, 2930, 1710, 1600, 1560, 1480, 1445, 1420, 1100 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 9.51 (dd, 1H, H-6), 8.97-8.36 (m, 3H, H-7,8,9), 7.77 (m, 5H, phenyl), 3.48 (s, 3H, CH₃); uv (ethanol): λ max 311, 244 nm.

Anal. Calcd. for C₁₄H₁₂ClN₃O₅: C, 49.79; H, 3.58; N, 12.44. Found: C, 50.12; H, 3.64; N, 12.38.

2-Methyl-3-phenyl-1-(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium (**5b**, A = PF₆) and 1-Methoxy-3-phenylpyrido[2,1-*f*]-*as*-triazinium Hexafluorophosphate (**12**, A = PF₆).

Reaction with Trimethyloxonium Hexafluorophosphate.

A suspension of 0.22 g (1 mmole) of 3-phenylpyrido[2,1-*f*]-*as*-triazinium-1-olate (**4b**) in 15 ml of chloroform was stirred at 25° with 0.21 g (1 mmole) of trimethyloxonium hexafluorophosphate for 4 hours. The reaction was mixed with 15 ml of ether. The precipitate was filtered and washed with ether to give 0.38 g (100%) of white crystals, mp 278-286°. The ¹H-nmr spectrum of the crude product showed the formation of 1-methoxy-3-phenylpyrido[2,1-*f*]-*as*-triazinium hexafluorophosphate (**12**, A = PF₆) and 2-methyl-3-phenyl-1-(2*H*)-oxopyrido[2,1-*f*]-*as*-triazinium hexafluorophosphate (**5b**, A = PF₆) in a ratio of 49:51.

The crude product (0.2 g) was boiled in 10 ml of 40% aqueous ethanol, the suspension was filtered while hot. The insoluble residue (0.08 g) was pure *N*-methyl derivative (**5b**, A = PF₆), mp 288-289°; ¹H-nmr (trifluoroacetic acid-DMSO-*d*₆): δ 9.20 (dd, 1H, H-6), 9.0-8.7 (m, 3H, H-7,8,9), 7.68 (m, 5H, phenyl), 3.60 (s, 3H, CH₃); from the ethanolic solution after cooling 0.09 g of white solid containing the *O*-methyl (**12**, A = PF₆) and *N*-methyl (**5b**, A = PF₆) derivatives in a ratio of 3:1 was obtained, mp 275-278°; ¹H-nmr (trifluoroacetic acid-DMSO-*d*₆): δ 9.50 and 9.20 (two doublets in a ratio of 3:1, H-6), 8.9-7.6 (m, 8H, H-7,8,9 and phenyl), 4.62 (s, OCH₃) and 3.60 (s, NCH₃) in a ratio of 3:1.

1-Amino-2-(1,3-dioxolan-2-yl)pyridinium Perchlorate (**6**).

A solution of 1.51 g (10 mmoles) of 2-(1,3-dioxolan-2-yl)pyridine [10] in 10 ml of dichloromethane was stirred at 0° with a solution of 1.87 g (10 mmoles) of *O*-tosylhydroxylamine in 40 ml of dichloromethane for 15 minutes, and at 25° for 3 hours. The reaction mixture was filtered, evaporated to 15 ml, mixed with 1 ml of 70% perchloric acid and 15 ml of ethyl acetate. The precipitate was filtered and recrystallized from acetonitrile-ethyl acetate to give 2.32 g (87%) of colorless needles, mp 89-90°; ir (potassium bromide): 3340, 3270, 3230, 3135, 3075, 3050, 2980, 2905, 1640, 1500, 1450, 1100 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 8.85 (d, 1H, H-6), 8.5-7.8 (m, 3H, H-3,4,5), 7.5 (s, 2H, NH₂), 6.30 (s, 1H, H-2'), 4.03 (s, 4H, H-4',5'); uv (ethanol): λ max 262 nm.

Anal. Calcd. for C₈H₁₁ClN₂O₆: C, 36.04; H, 4.16; N, 10.51. Found: C,

35.95; H, 4.20; N, 10.65.

3(4*H*)-Oxopyrido[2,1-*f*]-*as*-triazinium Perchlorate (**7**).

A mixture of 5.32 g (20 mmoles) of 1-amino-2-(1,3-dioxolan-2-yl)pyridinium perchlorate (**6**) and 12 g (200 mmoles) of urea was stirred at 100° in 40 ml of boron trifluoride acetic acid and 4 ml of water for an hour. The reaction mixture was evaporated to dryness *in vacuo*, the residue was mixed with 2 ml of ether. The precipitate was filtered and recrystallized from 130 ml of ethanol/water (4:1) to give 2.23 g (45%) of colorless needles, mp 235-236°; ir (potassium bromide): 3050, 2850, 1680, 1620, 1440, 1410, 1100 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 8.69 (dd, 1H, H-6), 8.45 (t, 1H, H-8), 8.29 (dd, 1H, H-9), 8.03 (t, 1H, H-7), 7.34 (s, 1H, H-1), 6.99 (s, 1H, NH); uv (ethanol): λ max 390, 325, 266 nm.

Anal. Calcd. for C₇H₆ClN₃O₅: C, 33.96; H, 2.44; N, 16.97. Found: C, 33.88; H, 2.57; N, 17.13.

Pyrido[2,1-*f*]-*as*-triazinium-3-olate (**8**).

A suspension of 0.25 g (1 mmole) of 3(4*H*)-oxo pyrido[2,1-*f*]-*as*-triazinium perchlorate (**7**) in 3 ml of methanol was stirred at 25° with a solution of 0.05 g (1.25 mmoles) of sodium hydroxide in 0.25 ml of water for 10 minutes. The precipitate was filtered, washed with ethyl acetate to give 0.14 g (95%) of yellow prisms, mp 113-114°. This compound decomposes during the thermal recrystallization. Therefore, the crude product was used for spectral investigations; ir (potassium bromide): 3200, 3110, 2990, 1660, 1600, 1460, 1425, 1100 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 7.84 (d, 1H, H-6), 7.18 (dd, 1H, H-9), 7.13 (t, 1H, H-8), 6.73 (t, 1H, H-7), 6.41 (s, 1H, H-1), 3.12 (s, 6H, CH₃OH); uv (ethanol): λ max 390, 327, 262, 228 nm, (chloroform): 396, 335, 269 nm; high resolution ms: *m/e* calcd. 147.0433, (*m/e* observed: 147.0430). The spectral data of the yellow crystals are in accordance with the complex structure: **8**·2MeOH·NaClO₄.

3-Hydroxy-1-phenyl pyrido[2,1-*f*]-*as*-triazinium Perchlorate (**10**).

A mixture of 2.6 g (8.7 mmoles) of 1-amino-2-benzoylpyridinium perchlorate [9] (**9**) and 5.2 g (87 mmoles) of urea was stirred at 160° in 20 g of polyphosphoric acid for an hour. The reaction mixture was dissolved in 100 ml of water saturated with sodium perchlorate. The precipitate was filtered, washed with water and recrystallized from acetonitrile-ethyl acetate to give 1.8 g (64%) of colorless crystals, mp 263-265°; ir (potassium bromide): 3300-2800 (broad), 3050, 3000, 1610, 1590, 1500, 1425, 1100 cm⁻¹; ¹H-nmr (deuterioacetonitrile): δ 9.34 (dd, 1H, H-6), 8.9-8.4 (m, 4H, H-7,8,9 and OH), 7.88 (m, 5H, phenyl); uv (ethanol): λ max 360, 308, 267, 238 nm.

Anal. Calcd. for C₁₃H₁₀ClN₃O₅: C, 48.24; H, 3.11; N, 12.98. Found: C, 48.29; H, 3.30; N, 12.98.

1-Phenylpyrido[2,1-*f*]-*as*-triazinium-5-ium-3-olate (**11**).

A suspension of 3.2 g (10 mmoles) of 3-hydroxy-1-phenylpyrido[2,1-*f*]-*as*-triazinium perchlorate (**10**) in 30 ml of ethanol was stirred at 25° with a solution of 0.56 g (10 mmoles) of potassium hydroxide in 15 ml of ethanol for 30 minutes. The reaction mixture was then mixed with 100 ml of chloroform, filtered and evaporated *in vacuo*. The residue was recrystallized from chloroform to give 1.4 g (64%) of yellow crystals, mp 282-284°; ir (potassium bromide): 3090, 3050, 1595, 1530, 1480, 1440, 1410 cm⁻¹; ¹H-nmr (DMSO-*d*₆): δ 8.85 (dd, 1H, H-6), 8.3-7.7 (m, 3H, H-7,8,9), 7.7-7.5 (m, 5H, phenyl); uv (ethanol): λ max 372, 305, 267, 238 nm (first uv maxima in different solvents: water: 354; ethanol: 372; acetonitrile: 385; chloroform: 390 nm).

Anal. Calcd. for C₁₃H₉N₃O: C, 69.94; H, 4.06; N, 18.82. Found: C, 69.79; H, 3.99; N, 18.60.

3-Methoxy-1-phenylpyrido[2,1-*f*]-*as*-triazinium Perchlorate (**13**, A = ClO₄).

A. Reaction with Trimethyloxonium Hexafluorophosphate.

A suspension of 0.22 g (1 mmole) of 1-phenylpyrido[2,1-*f*]-*as*-triazinium-3-olate (**11**) in 5 ml of chloroform was stirred at 25° with 0.21 g (1 mmole) of trimethyloxonium hexafluorophosphate for 20 hours. The re-

action mixture was treated with 15 ml of ether, filtered and the crystals were suspended in 10 ml of water saturated with sodium perchlorate. The precipitate was filtered, washed with water and recrystallized from aqueous ethanol to give 0.27 g (83%) of white crystals, mp 217-219°; ir (potassium bromide): 3120, 3100, 3000, 2950, 2860, 2580, 1560, 1485, 1430, 1100 cm^{-1} ; $^1\text{H-nmr}$ (perdeuterionitromethane): δ 9.50 (dd, 1H, H-6), 9.0-8.4 (m, 3H, H-7,8,9), 8.1-7.6 (m, 5H, phenyl), 4.33 (s, 3H, CH_3).

Anal. Calcd. for $\text{C}_{13}\text{H}_{12}\text{ClN}_3\text{O}_5$: C, 47.94; H, 3.71; N, 12.90. Found: C, 48.11; H, 3.87; N, 12.73.

B. Reaction with Methyl Iodide.

A suspension of 0.22 g (1 mmole) of 1-phenylpyrido[2,1-*f*]-*as*-triazinium-3-olate (**11**) in 5 ml of acetonitrile was stirred at 25° with 0.5 ml of methyl iodide for 5 days. The reaction was evaporated to dryness *in vacuo* and the residue (no N-CH_3 peak in $^1\text{H-nmr}$!) was suspended in 5 ml of water saturated with sodium perchlorate. The precipitate was filtered and recrystallized from aqueous ethanol to give 0.2 g (61%) of white crystals with the same mp, ir, $^1\text{H-nmr}$ and uv as above.

C. Reaction with Methyl Tosylate.

A solution of 0.22 g (1 mmole) of 1-phenylpyrido[2,1-*f*]-*as*-triazinium-3-olate (**11**) in 5 ml of acetonitrile was refluxed with 1 g (5.3 mmoles) of methyl tosylate for 3 hours. The reaction mixture was evaporated *in vacuo*, the residue (no N-CH_3 peak in $^1\text{H-nmr}$!) was dissolved in 5 ml of ethyl acetate, and mixed with 0.5 ml of 70% perchloric acid. The precipitate was filtered and recrystallized from a mixture of 3 ml of acetonitrile and 10 ml of ethyl acetate to give 0.31 g (96%) of white crystals with the same mp, ir, $^1\text{H-nmr}$ and uv as above.

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