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Iminophosphorane-Mediated Annelation of a Pyridine Ring into a Preformed Pyridine One: Synthesis of Naphthyridine , Pyrido[1,2-c] pyrimidine and Pyrido[1,2-c]quinazoline Derivatives

Pedro Molina*, Angeles Lorenzo, Enrique Aller

Departamento de Química Orgánica, Facultad de Química, Universidad de Murcia, Campus de Espinardo, E-30071, Murcia, Spain

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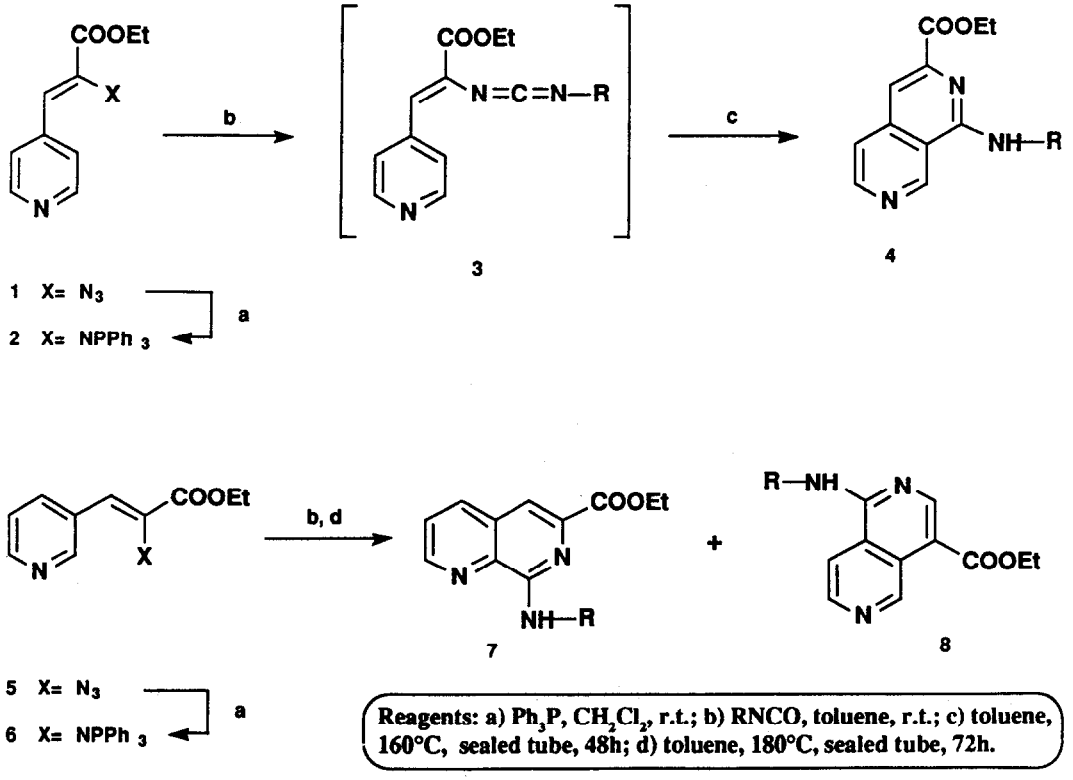
Abstract.- Aza Wittig-type reaction of iminophosphoranes **2** *and* **6** *, prepared from 4- and 3-formylpyridines by sequential treatment with ethyl azidoacetate and triphenylphosphine, with isocyanates leads to 2,7-naphthyridine* **4**, *1,7-naphthyridine* **7** *and 2,6-naphthyridine* **8** *respectively. Iminophosphoranes* **10** *and* **22** *undergo pyrido annelation by reaction with isocyanates, carbon dioxide, carbon disulfide and acyl chlorides to give pyrido[1,2-c]pyrimidine* **11-14** *and pyrido[1,2-c]quinazoline derivatives* **23-26**.

Current interest in the chemistry of naphthyridine derivatives has continued to grow because of their physiological activities and the behaviour of this ring system as a ligand[1]. The two general methods for obtaining 1,*n* -naphthyridines (*n* = 5, 6, 7, 8) are based either on the Skraup reaction or on EMME (ethoxymethylenemalonate) synthesis and aminopyridines are therefore the required starting compounds. The remaining 2,*n* -naphthyridines (*n* = 6,7) have recieved less attention than the aforementioned and the reported preparative methods for these compounds entail starting with either cyanopyridines or with their carboxamide analogues[2].

In the course of our studies directed towards the synthesis of fused heterocycles based on heterocyclization reactions of carbodiimides, we have developed the so-called tandem aza-Wittig/electrocyclization strategy for the synthesis of fused pyridines. This approach is centered on the aza Wittig-type reaction of β-aryl(heteroaryl)vinyl iminophosphoranes with isocyanates or isothiocyanates to give a 2-aza-hexatriene moiety containing a carbodiimide function at one end. Pyrido annelation is achieved by electrocyclic ring-closure with the aryl(heteroaryl) group as 2π-component followed by [1,3]proton shift. This pyrido annelation methodology allows the *c* -fusion of a pyridine ring both onto a preformed five-membered heterocycle[3] and an aromatic ring[4]. As a further extension of the above methodology we would like now to report a new approach to the synthesis of the not readily available 2,6- and 2,7-naphthyridines and of the previously unreported pyrido[1,2-c]pyrimidin-9-ium ring system by thermally induced 6π-electrocyclization.

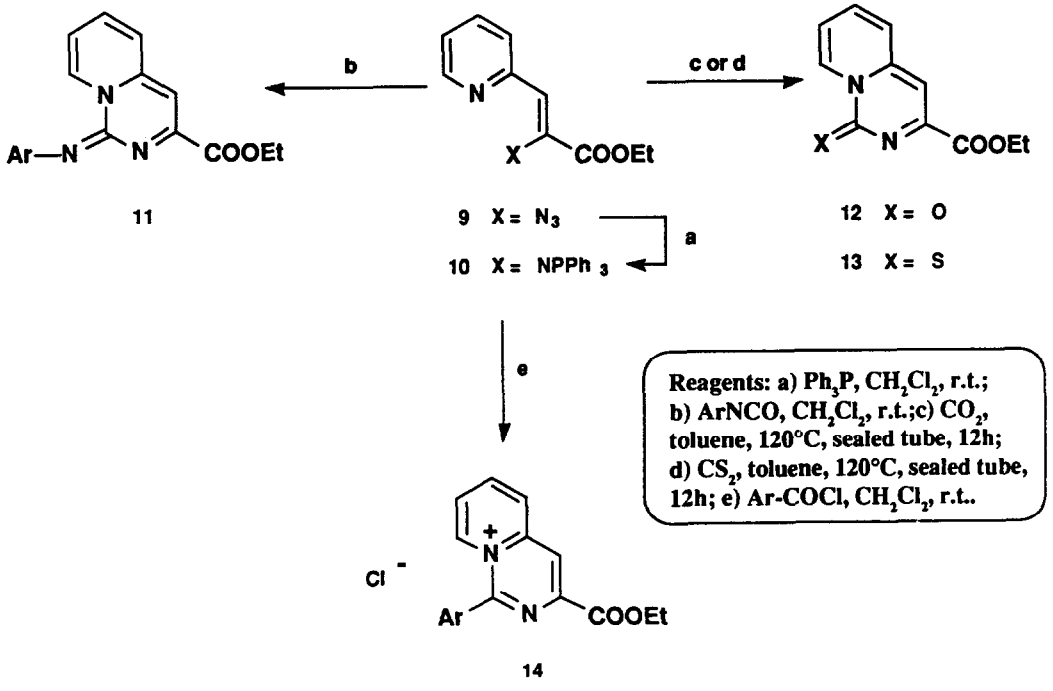
Results.- 4-Formylpyridine was condensed with ethyl azidoacetate in the presence of sodium ethoxide at -17°C to give **1** in 30% yield. The preparation of the iminophosphorane **2** was accomplished in 80% yield by Staudinger reaction of **1** with triphenylphosphine in dry dichloromethane at room temperature. Aza Wittig-type reaction of iminophosphorane **2** with isocyanates in dry toluene at room temperature led to the corresponding carbodiimides **3** (as evidenced by i.r.) which underwent cyclization in toluene in a glass sealed tube at 160°C to give ethyl 1-amino-2,7-naphthyridine-3-carboxylates **4** in 50-59% yields. Iminophosphorane **6**, available from 3-formylpyridine in 53% overall yield, under the same reaction conditions only gave the corresponding carbodiimide and no cyclized products were observed. However, when the reaction was carried out at 180°C a mixture (1:1) of 1,7-naphthyridine **7** and 2,6-naphthyridine **8** was obtained in moderate yields (44-47%) (Scheme 1). Compounds **7** and **8** were easily separated by column chromatography. Despite its apparent simplicity 6π-electrocyclizations involving a pyridine ring as 2π-component are rare. To our knowledge it has been mentioned[5] that FVP of 2- and 4-butadienylpyridines leads to dihydroquinoline and dihydroisoquinoline respectively, but it remains as the sole example.



Scheme 1

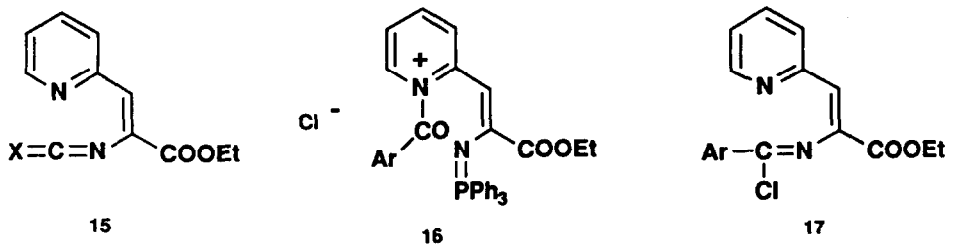
The iminophosphorane **10**, readily available from the azide[6] **9** and triphenylphosphine in 97% yield, reacted with aromatic isocyanates in dry dichloromethane at room temperature to give pyrido[1,2-c]pyrimidines **11**

in excellent yields (82-90%). The reaction with carbon dioxide or carbon disulfide in a sealed glass tube at 120°C resulted in the formation of **12** (83%) and **13** (93%) respectively. Iminophosphorane **10** also reacted with aroyl chlorides in dry dichloromethane at room temperature to give the previously unreported pyrido[1,2-c]pyrimidin-9-ium chlorides **14** in excellent yields (84-94%) (Scheme 2).

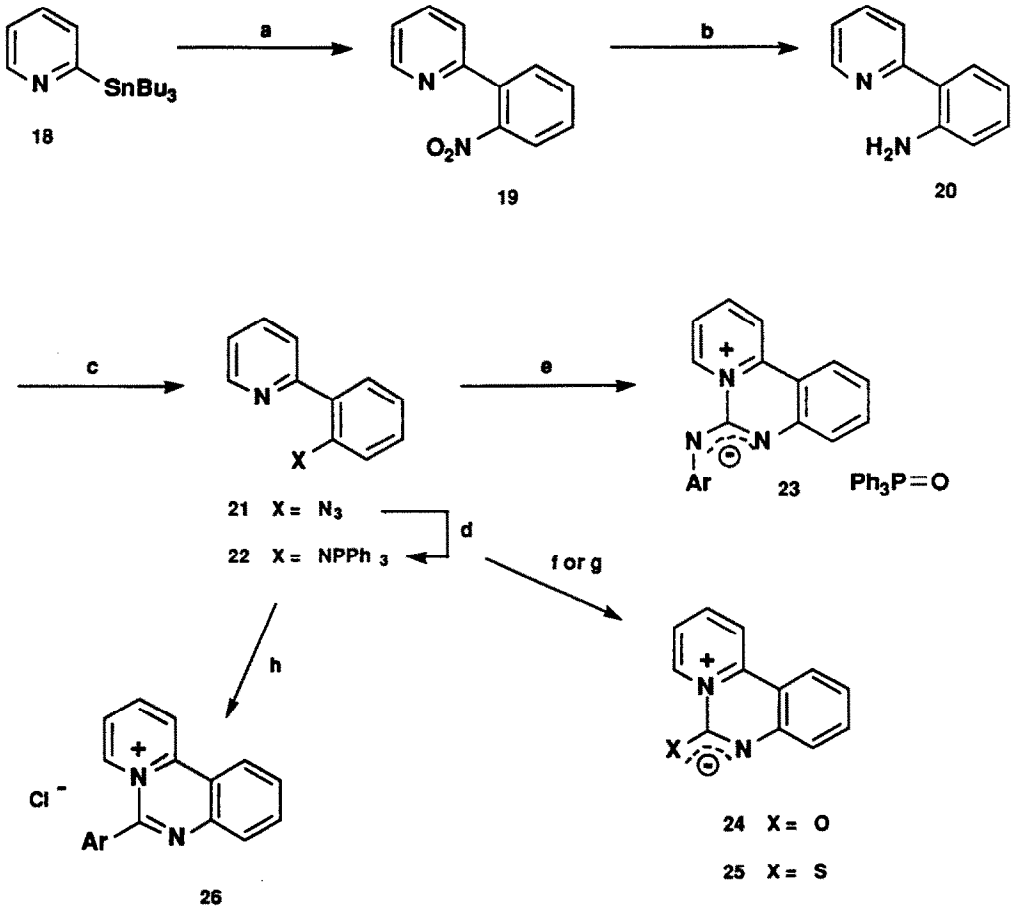


Scheme 2

The formation of compounds **11-13** can be understood by initial formation of an 1,5-diaza-hexatriene type **15** followed by 6π-electrocyclization to give the cyclic valence tautomer pyrimidine ring[7], whereas compounds **14** could be formed either by N-acylation of the pyridine ring to give **16** and subsequent intramolecular aza-Wittig reaction or by initial formation of an imidoyl chloride[8] **17** as intermediate which undergoes ring-closure by intramolecular nucleophilic attack of the pyridine nitrogen atom on the imidoyl group.



In order to investigate the generality of this electrocyclization process a variation was considered. It was of interest to see what would happen if the central C-C double bond of the 1,5-diaza-hexatriene is part of an aromatic ring. Thus, iminophosphorane **22** was prepared from the azide **21** in 89% yield. Compound **21** was prepared from 2-tributylstannylpyridine[9] **18** in three steps in 48% overall yield. Coupling reaction between **18** and o-nitroiodobenzene using $PdCl_2(PPh_3)_2$ as a catalyst led to 2-(o-nitrophenyl)pyridine **19** in 75% yield, which was reduced with sodium borohydride-copper(II) sulfate system[10] to give the corresponding amine **20** in 72% yield. Finally, standard azidation via diazonium salt afforded the 2-(o-azidophenyl)pyridine **21** in 92% yield.



Reagents: a) o-nitroiodobenzene, $PdCl_2(PPh_3)_2$, THF, 100°C, 24h; b) $NaBH_4$, $CuSO_4$, EtOH, 0°C; c) $NaNO_2$, HCl, 0°C → NaN_3; d) PPh_3, CH_2Cl_2, r.t.; e) ArNCO, CH_2Cl_2, r.t.; f) CO_2, toluene, sealed tube, 70°C, 12h; g) CS_2, toluene, sealed tube, 120°C, 12h; h) Ar-COCl, toluene, reflux, 24h.

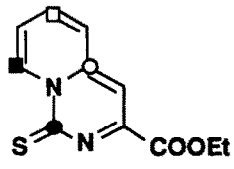
Scheme 3

Iminophosphorane **22** reacted with aromatic isocyanates in dry dichloromethane at room temperature to give in almost all cases a complex of anhydro 6-arylaminopyrido[1,2-c]quinazolin-7-ium hydroxide and triphenyl

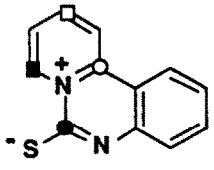
phosphine oxide **23** in near 75% yields. The isolation of these complexes is probably due to the ability of triphenyl phosphine oxide, which is formed as by-product in the aza Wittig-type reaction between **22** and the isocyanate, to act as a crystallization aid. In this context, recent examples involving the use of triphenyl phosphine oxide in cocrystallization processes have been reported[11]. Iminophosphorane **22** also reacted with carbon dioxide at 70°C and carbon disulfide at 120°C in a sealed tube to give the pyrido[1,2-c]quinazolines **24** and **25** respectively; the reaction with aroyl chlorides in toluene at reflux temperarure led to 6-arylpyrido[1,2-c]quinazolinium chlorides **26** in excellent yields (81-94%) (Scheme 3).

Comparison of the ^{13}C n.m.r. spectra of compounds **11-13** with those compounds **23-25** reveals that the former can be represented as neutral structures and the latter rather as zwitterionic species. Thus, for compounds **13** and **25** (X=S) the differences in the chemical shifts are quite illustrative (Table 1). In addition, the chemical shifts of the C-2, C-4 and C-6 of the pyridine ring in compound **25** are very closed to those found in the salts **26**.

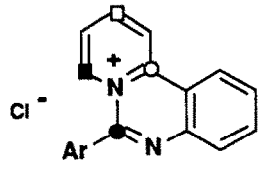
Table 1. ^{13}C Chemical Shifts of Some Representative Carbon Atoms in Compounds 13, 24, and 25.



13



25



26

Carbon atom	Comp. **13**	Δδ	Comp. **25**	Δδ	Comp. **26**
●	173.26	7.2	166.06		
■	135.10	-2.6	137.70	0.2	137.53
□	139.64	-2.1	141.79	-2.8	144.63
O	147.14	2.2	145.02	-0.7	145.70

In summary, the present study demonstrates that the tandem aza Wittig/electrocyclic ring-closure strategy affords a new and general entry to a variety of naphthyridines. Because of their simplicity, easy access of the starting materials and the good yield in the cyclization step, the investigated reactions provide a method for the preparation of different naphthyridines and pyrido[1,2-c]pyrimidines, which compares favourably with other approaches to these systems.

EXPERIMENTAL

All melting points were determined on a Kofler hot-plate melting point apparatus and are uncorrected. IR spectra were obtained as Nujol emulsions on a Nicolet-5DX spectrophotometer. NMR spectra were recorded on a Bruker AC-200 (200 MHz) and on a Varian Unity-300 (300 MHz). Mass spectra were recorded on a Hewlett-Packard 5993C spectrometer. Microanalyses were performed on a Perkin-Elmer 240C instrument.

General Procedure for the Preparation of Ethyl α-Azido-β-(pyridyl)acrylates 1 and 5.

To a well-stirred solution containing sodium (1.29 g, 56.1 mmol) in dry ethanol (25 ml), a solution of ethyl azidoacetate (7.23 g, 56.1 mmol) and the corresponding formylpyridine (2.0 g, 18.7 mmol) was added dropwise at -17°C, under nitrogen. The reaction mixture was stirred at this temperature for 5h. After this, it was poured into aqueous 30% ammonium chloride (50 ml) and was extracted with ethyl ether (3x15 ml). The combined organic layers were washed with water (3x20 ml) and dried over anhydrous sodium sulfate. The solvent was removed under reduced pressure and the crude product was chromatographed on a silica gel column, eluting with n-hexane/ethyl acetate (3:1) to give **1** or **5**, respectively.

1: Ethyl α-Azido-β-(4-pyridyl)acrylate, (30%), as a yellow oil. (Found: C, 54.91; H, 4.53; N, 25.49. $C_{10}H_{10}N_4O_2$ requires: C, 55.04; H, 4.62; N, 25.67); i.r. (Nujol): 2129, 1717, and 1273 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.41 (t, 3H, ^3J=7.1 Hz, CH_3), 4.38 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.76 (s, 1H, H_β), 7.62 (m, 2H, H_3, H_5), 8.62 (m, 2H, H_2, H_6); ^{13}C n.m.r. δ ($CDCl_3$): 14.03 (CH_3), 62.67 (CH_2O), 121.25 (C_β), 123.81 (C_3, C_5), 129.83 (C_α), 140.05 (C_4), 150.03 (C_2, C_6), 162.56 (C=O); m/z (%): 218 (M^+, 5), 118 (100), 78 (7).

5: Ethyl α-Azido-β-(3-pyridyl)acrylate, (54%), as a yellow oil. (Found: C, 54.95; H, 4.56; N, 25.41. $C_{10}H_{10}N_4O_2$ requires: C, 55.04; H, 4.62; N, 25.67); i.r. (Nujol): 2130, 1715, and 1250 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.41 (t, 3H, ^3J=7.1 Hz, CH_3), 4.38 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.84 (s, 1H, H_β), 7.32 (dd, 1H, ^3J=8.2, 4.8 Hz, H_5), 8.31 (dt, 1H, ^3J=8.2 Hz, ^4J=1.9 Hz, H_4), 8.51 (dd, 1H, ^3J=4.8 Hz, ^4J=1.6 Hz, H_6), 8.82 (d, 1H, ^4J=2.1 Hz, H_2); ^{13}C n.m.r. δ ($CDCl_3$): 13.96 (CH_3), 62.37 (CH_2O), 120.71 (C_β), 123.16 (C_5), 127.65 (C_α), 129.19 (C_3), 136.52 (C_4), 149.38 (C_6), 151.32 (C_2), 162.70 (C=O); m/z (%): 218 (M^+, 9), 190 (12), 145 (9), 118 (100).

General Procedure for the Preparation of Ethyl β-(Pyridyl)-α-(tryphenylphosphoranilidenamino)-acrylates 2 , 6, 10 and 22.

To a solution of the appropriate azide **1**, **5**, **9**, or **21** (7.1 mmol) in dry dichloromethane (25 ml) was added dropwise at room temperature a solution of triphenylphosphine (1.86 g, 7.1 mmol) in the same solvent (30 ml), and the reaction mixture was stirred for 2h. The solvent was removed under reduced pressure and the residual material was slurried with cold n-hexane (25 ml). The solid formed was chromatographed on a silica gel column, eluting with ethyl acetate/n-hexane (2:1) and further recrystallized from dichloromethane/n-hexane.

2: Ethyl β-(4-Pyridyl)-α-(triphenylphosphoranilidenamino)acrylate, (87%), m.p. 121-123°C, as yellow prisms. (Found: C, 74.43; H, 5.64; N, 6.05. $C_{28}H_{25}N_2O_2P$ requires: C, 74.32; H, 5.57; N, 6.19); i.r. (Nujol): 1711, 1217, 1109, and 712 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 0.99 (t, 3H, ^3J=7.1 Hz, CH_3), 3.84 (q, 2H, ^3J=7.1 Hz, CH_2), 6.50 (d, 1H, $^4J_{P-H}$=7.4 Hz, H_β), 7.45 (m, 9H), 7.69 (m, 6H), 7.96 (d, 2H, ^3J=6.0 Hz, H_3, H_5), 8,43 (d, 2H, ^3J=6.0 Hz, H_2, H_6);

^{13}C n.m.r. δ ($CDCl_3$): 13.86 (CH_3), 61.01 (CH_2O), 111.70 (C_β, $^3J_{P-C}$=19.9 Hz), 123.00 (C_3, C_5), 128.22 (phenyl C_m, $^3J_{P-C}$=12.2 Hz), 131.21 (phenyl C_p, $^4J_{P-C}$=2.9 Hz), 131.98 (phenyl C_i, $^1J_{P-C}$=103.7 Hz), 132.24 (phenyl C_o, $^2J_{P-C}$=9.8 Hz), 141.39 (C_α, $^2J_{P-C}$=6.8 Hz), 145.72 (C_4), 148.89 (C_2, C_6), 166.95 (C=O, $^3J_{P-C}$=8.0 Hz); m/z (%): 452 (M^+, 14), 183 (100), 117 (45).

6: Ethyl β-(3-Pyridyl)-α-(triphenylphosphoranilidenamino)acrylate, (98%), m.p. 125-127°C, as yellow prisms. (Found: C, 74.18; H, 5.40; N, 6.07. $C_{28}H_{25}N_2O_2P$ requires: C, 74.32; H, 5.57; N, 6.19); i.r. (Nujol): 1705, 1437, 1240, 1111, and 712 cm^{-1}; ^{1}H n.m.r. δ ($CDCl_3$): 0.99 (t, 3H, ^{3}J=7.1 Hz, CH_3), 3.85 (q, 2H, ^{3}J=7.1 Hz, CH_2O), 6.62 (d, 1H, $^4J_{P-H}$=7.3 Hz, H_β), 7.14 (dd, 1H, ^{3}J=8.0, 4.8 Hz, H_5), 7.45 (m, 9H), 7.71 (m, 6H), 8.31 (dd, 1H, ^{3}J =4.7 Hz, ^{4}J=1.5 Hz, H_6), 8.70 (dt, 1H, ^{3}J=8.1 Hz, ^{4}J=1.6 Hz, H_4), 9.07 (d, 1H, ^{4}J=1.8 Hz, H_2); ^{13}C n.m.r. δ ($CDCl_3$): 13.87 (CH_3), 60.79 (CH_2O), 111.59 (C_β, $^3J_{P-C}$=20.2 Hz), 122.67 (C_5), 128.13 (phenyl C_m, $^3J_{P-C}$=12.2 Hz), 131.00 (phenyl C_p, $^4J_{P-C}$=2.9 Hz), 132.16 (phenyl C_o, $^2J_{P-C}$=9.8 Hz), 132.39 (phenyl C_i, $^1J_{P-C}$=103.4 Hz), 134.30 (C_3, $^4J_{P-C}$=1.2 Hz), 135.24 (C4), 138.62 (C_α, $^2J_{P-C}$=6.6 Hz), 145.78 (C6), 150.37 (C2), 167.21 (C=O, $^3J_{P-C}$=7.4 Hz); ^{31}P n.m.r. δ ($CDCl_3$): 9.22; m/z (%): 452 (M^+, 38), 183 (100), 108 (61).

10: Ethyl β-(2-Pyridyl)-α-(triphenylphosphoranilidenamino)acrylate, (97%), m.p. 103-105°C, as yellow prisms. (Found: C, 74.20; H, 5.43; N, 6.05. $C_{28}H_{25}N_2O_2P$ requires: C, 74.32; H, 5.57; N, 6.19); i.r. (Nujol): 1707, 1570, 1437, 1237, 1111, and 719 cm^{-1}; ^{1}H n.m.r. δ ($CDCl_3$): 1.03 (t, 3H, ^{3}J=7.1 Hz, CH_3), 3.86 (q, 2H, ^{3}J=7.1 Hz, CH_2O), 6.95 (m, 2H), 7.46 (m, 10H), 7.72 (m, 6H), 8.54 (d, 1H, ^{3}J=4.5 Hz, H_6), 8.99 (d, 1H, ^{3}J=8.1 Hz, H_3); ^{13}C n.m.r. δ ($CDCl_3$): 13.87 (CH_3), 60.90 (CH_2O), 116.03 (C_β, $^3J_{P-C}$=19.6 Hz), 119.67 (C_3), 124.01 (C_5), 128.09 (phenyl C_m, $^3J_{P-C}$=12.2 Hz), 130.98 (phenyl C_p, $^4J_{P-C}$=2.8 Hz), 132.22 (phenyl C_o, $^2J_{P-C}$=9.7 Hz), 132.46 (phenyl C_i, $^1J_{P-C}$=103.6 Hz), 1135.12 (C4), 139.71 (C_α, $^2J_{P-C}$=7.1 Hz), 148.87 (C6), 157.48 (C2), 167.55 (C=O, $^3J_{P-C}$=7.9 Hz); ^{31}P n.m.r. δ ($CDCl_3$): 9.47; m/z (%): 452 (M^+, 7), 262 (39), 201 (85), 183 (100), 108 (66).

22: 2-(o-Triphenylphosphoranilidenamino)phenylpyridine, (90%), m.p. 122-123°C, as yellow prisms. (Found: C, 80.99; H, 5.32; N, 6.36. $C_{29}H_{23}N_2P$ requires: C, 81.09; H, 5.39; N, 6.51); i.r. (Nujol): 1437, 1105, and 754 cm^{-1}; ^{1}H n.m.r. δ ($CDCl_3$): 6.56 (dt, 1H, ^{3}J=7.8 Hz, ^{4}J=1.1 Hz, aryl H_3), 6.76 (td, 1H, ^{3}J=7.3 Hz, ^{4}J= 1.1 Hz, aryl H_5), 6.89 (td, 1H, ^{3}J=7.4 Hz, ^{4}J= 1.7 Hz, aryl H_4), 7.11 (ddd, 1H, ^{3}J=7.4, 5.0 Hz, ^{4}J= 1.1 Hz, H_5), 7.45 (m, 9H), 7.67 (m, 8H), 8.34 (d, 1H, ^{3}J = 7.9 Hz, H_3), 8.67 (dt, 1H, ^{3}J=5.0 Hz, ^{4}J=0.8 Hz, H_6); ^{13}C n.m.r. δ ($CDCl_3$): 117.75 (aryl C_5, $^5J_{P-C}$=0.6 Hz), 120.49 (C_5), 122.41 (aryl C_3, $^3J_{P-C}$=10.5 Hz), 126.25 (C_3), 128.42 (phenyl C_m, $^3J_{P-C}$=12.0 Hz), 128.54 (aryl C_4), 130.57 (aryl C_6, $^4J_{P-C}$=1.9 Hz), 131.10 (phenyl C_i, $^1J_{P-C}$=99.8 Hz), 132.46 (phenyl C_2, $^2J_{P-C}$=9.7 Hz), 134.05 (C_4), 134.46 (aryl C_1), 148.41 (aryl C_2, $^2J_{P-C}$=1.0 Hz), 148.82 (C_6), 159.75 (C_2, $^4J_{P-C}$=1.0 Hz); ^{31}P n.m.r. δ ($CDCl_3$): 1.35; m/z (%): 430 (M^+, 9), 183 (100), 168 (51), 108 (35), 77 (40).

General Procedure for the Preparation of Ethyl 1-Alkyl(aryl)amino-2,7-naphthyridine-3-carboxylates 4.

To a solution of the iminophosphorane **2** (0.25 g, 0.55 mmol) in dry toluene (15 ml) was added the appropriate isocyanate (0.55 mmol). The reaction mixture was stirred at room temperature for 2h and then heated at 160°C in a sealed tube for 48h. After cooling, the solvent was removed and the residual material was slurried with cold ethanol (15 ml) and the separated solid was recrystallized from ethanol to give **4**.

4a: 1-Benzylamino, (52%), m.p. 165-167°C, as yellow prisms. (Found: C, 70.21; H, 5.43; N, 13.41. $C_{18}H_{17}N_3O_2$ requires: C, 70.34; H, 5.57; N, 13.67); i.r. (Nujol): 3347, 1719, and 1231 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$); 1.45 (t, 3H, ^3J=7.1 Hz, CH_3), 4.43 (q, 2H, ^3J=7.1 Hz, CH_3-CH_2O), 4.83 (d, 2H, ^3J=5.1 Hz, -CH_2-NH), 6.96 (t, 1H, ^3J=5.1 Hz, NH), 7.22 (m, 3H), 7.40 (m, 3H), 7.61 (s, 1H, H_4), 8.44 (d, 1H, ^3J=5.6 Hz, H_6), 9.27 (s, 1H, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 14.18 (CH_3), 45.46 (CH_2-NH), 61.45 (CH_3-CH_2O), 111.40 (C_4), 114.41 (C_{8a}), 120.45 (C_5), 127.20 (phenyl C_p), 128.29 (phenyl C_m), 128.50 (phenyl C_o), 138.72 (phenyl C_i), 140.58 (C_{4a}), 144.63 (C_3), 146.65 (C_8), 147.07 (C_6), 155.23 (C_1), 165.71 (C=O); m/z (%): 307 (M^+, 74), 233 (79), 201 (18), 106 (58), 91 (100).

4b: 1-Phenylamino, (59%), m.p. 207-209°C, as yellow prisms. (Found: C, 69.50; H, 5.00; N, 14.12. $C_{17}H_{15}N_3O_2$ requires: C, 69.61; H, 5.15; N, 14.33); i.r. (Nujol): 3405, 1692, 1260, and 760 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.40 (t, 3H, ^3J = 7.1 Hz, CH_3), 4.38 (q, 2H, ^3J = 7.1 Hz, CH_2O), 7.08 (t, 1H, ^3J=7.3 Hz, phenyl H_p), 7.39 (t, 2H, ^3J=7.8 Hz, phenyl H_m), 7.90 (s, 1H, H_4), 7.91 (d, 1H, ^3J=5.6 Hz, H_5), 8.20 (d, 2H, ^3J=8.0 Hz, phenyl H_o), 8.78 (d, 1H, ^3J=5.6 Hz, H_6), 9.75 (s, 1H, NH), 9.99 (s, 1H, H_8); ^{13}C n.m.r. δ (DMSO): 14.07 (CH_3), 61.01 (CH_2O), 112.88 (C_4), 114.56 (C_{8a}), 120.31 (phenyl C_o), 120.50 (C_5), 122.38 (phenyl C_p), 128.29 (phenyl C_m), 140.32 (C_{4a}), 130.38 (phenyl C_i), 143.14 (C_3), 147.75 (C_6), 148.10 (C_8), 152.53 (C_1), 164.73 (C=O); m/z (%): 293 (M^+, 42), 264 (14), 220 (53), 219 (100), 218 (95), 77 (45).

4c: 1-(4-Methylphenyl)amino, (54%), m.p. 211-212°C, as yellow prisms. (Found: C, 70.20; H, 5.38; N, 13.93. $C_{18}H_{17}N_3O_2$ requires: C, 70.34; H, 5.57; N, 13.67); i.r. (Nujol): 3343, 1715, 1242, and 810 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.40 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 2.32 (s, 3H, CH_3-Ar), 4.37 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.18 (d, 2H, ^3J=8.3 Hz, aryl H_m), 7.86 (s, 1H, H_4), 7.88 (d, 1H, ^3J=5.5 Hz, H_5), 8.07 (d, 2H, ^3J=8.3 Hz, aryl H_o), 8.76 (d, 1H, ^3J=5.5 Hz, H_6), 9.68 (s, 1H, NH), 9.97 (s, 1H, H_8); ^{13}C n.m.r. δ (DMSO): 14.07 (CH_3-CH_2O), 20.41 (CH_3-Ar), 60.96 (CH_2O), 112.47 (C_4), 114.30 (C_{8a}), 120.40 (aryl C_o), 120.47 (C_5), 128.68 (aryl C_m), 131.27 (aryl C_p), 137.82 (aryl C_i), 140.32 (C_{4a}), 143.29 (C_3), 147.61 (C_6), 148.00 (C_8), 152.58 (C_1), 164.77 (C=O); m/z (%): 307 (M^+, 100), 278 (21), 234 (28), 233 (95), 91 (51).

4d: 1-(4-Fluorophenyl)amino, (50%), m.p. 216-218°C, as yellow prisms. (Found: C, 65.39; H, 4.40; N, 13.43. $C_{17}H_{14}FN_3O_2$ requires: C, 65.59; H, 4.53; N, 13.50); i.r. (Nujol): 3331, 1723, 1260, and 829 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.39 (t, 3H, ^3J=7.1 Hz, CH_3), 4.36 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.20 (t, 2H, ^3J=8.9 Hz, aryl Hm), 7.89 (s, 1H, H4), 7.91 (d, 1H, ^3J=5.5 Hz, H_5), 8.20 (dd, 2H, ^3J=8.9 Hz, $^4J_{F\text{-}H}$=5.0 Hz, aryl H_o), 8.77 (d, 1H, ^3J=5.5 Hz, H_6), 9.77 (s, 1H, NH), 9.95 (s, 1H, H_8); ^{13}C n.m.r. δ (DMSO): 14.06 (CH_3), 61.03 (CH_2O), 112.81 (C_4), 114.45 (C_{8a}), 114.75 (aryl C_m, $^2J_{F\text{-}C}$=22.0 Hz), 120.51 (C_5), 121.98 (aryl C_o, $^4J_{F\text{-}C}$=7.5 Hz), 136.72 (aryl C_i, $^4J_{F\text{-}C}$=2.5 Hz), 140.30 (C_{4a}), 143.05 (C_3), 147.80 (C_6), 148.02 (C_8), 152.43 (C_1), 157.60 (aryl C_p, $^1J_{F\text{-}C}$=239.3 Hz), 164.68 (C=O); m/z (%): 311 (M^+, 62), 237 (100), 95 (39).

4e: 1-(4-Methoxyphenyl)amino, (56%), m.p. 209-210°C, as yellow prisms. (Found: C, 66.95; H, 5.12; N, 12.81. $C_{18}H_{17}N_3O_3$ requires: C, 66.86; H, 5.30; N, 13.00); i.r. (Nujol): 3331, 1713, 1246, and 828 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.39 (t, 3H, ^3J = 7.1 Hz, CH_3-CH_2O), 3.80 (s, 3H, CH_3O-Ar), 4.37 (q, 2H, ^3J = 7.1 Hz, CH_2O), 6.97 (d, 2H, ^3J=8.8 Hz, aryl H_m), 7.82 (s, 1H, H_4), 7.86 (d, 1H, ^3J=5.5 Hz, H_5), 8.08 (d, 2H, ^3J=8.8 Hz, aryl H_o), 8.75 (d, 1H, ^3J=5.5 Hz, H_6), 9.64 (s, 1H, NH), 9.94 (s, 1H, H_8);^{13}C n.m.r. δ (DMSO): 14.07 (CH_3-CH_2O), 55.13 (CH_3O-Ar), 60.94 (CH_2O), 112.14 (C_4), 113.45 (aryl C_m), 114.43 (C_{8a}), 120.42 (C_5), 122.01 (aryl C_o), 133.48 (aryl C_i), 140.30 (C_{4a}), 143.37 (C_3), 147.66 (C_6), 147.96 (C_8), 152.64 (C_1), 154.83 (aryl C_p), 164.79 (C=O); m/z (%): 323 (M^+, 100), 249

(42), 234 (90).

General Procedure for the Preparation of Ethyl 8-Arylamino-1,7-naphthyridine-6-carboxylates 7 and Ethyl 1-Arylamino-2,6-naphthyridine-3-carboxylates 8.

To a solution of iminophosphorane **6** (0.5 g, 1.1 mmol) in dry toluene (25 ml) was added the appropriate isocyanate (1.1 mmol). The reaction mixture was stirred at room temperature for 2h and then heated at 180°C in a sealed glass tube for 72h. After cooling, the solvent was removed and the crude product was chromatographed on silica gel column, eluting with ethyl acetate/n-hexane (2:1) to give **7** and **8** respectively.

7a: 8-Phenylamino, (22%), m.p. 104-105°C, as yellow prisms. (Found: C, 69.40; H, 5.03; N, 14.16. $C_{17}H_{15}N_3O_2$ requires: C, 69.61; H, 5.15; N, 14.33); i.r. (Nujol): 3380, 1709, and 1256 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.49 (t, 3H, ^3J=7.1 Hz, CH_3), 4.47 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.06 (t, 1H, ^3J=7.3 Hz, phenyl H_p), 7.40 (t, 2H, ^3J=7.9 Hz, phenyl H_m), 7.57 (dd, 1H, ^3J=8.2, 4.3 Hz, H_3), 7.87 (s, 1H, H_5), 8.08 (dd, 1H, ^3J=8.2 Hz, ^4J=1.3 Hz, H_4), 8.12 (d, 2H, ^3J=8.3 Hz, phenyl H_o), 8.84 (dd, 1H, ^3J=4.3 Hz, ^4J=1.3 Hz, H_2), 9.12 (s, 1H, NH); ^{13}C n.m.r. δ ($CDCl_3$): 14.26 (CH_3), 61.43 (CH_2O), 113.58 (C_5), 118.73 (phenyl C_o), 122.27 (phenyl C_p), 125.56 (C_3), 128.92 (phenyl C_m), 130.75 (C_{4a}), 135.25 (C_{8a}), 136.18 (C_4), 139.81 (phenyl C_i), 140.84 (C_6), 150.16 (C_2), 152.17 (C_8), 165.80 (C=O); m/z (%): 293 (M^+, 26), 220 (100), 143 (32), 93 (14), 77 (81).

7b: 8-(4-Methylphenyl)amino, (23%), m.p. 180-181°C, as yellow prisms. (Found: C, 70.28; H, 5.40; N, 13.61. $C_{18}H_{17}N_3O_2$ requires: C, 70.34; H, 5.57; N, 13.67); i.r. (Nujol): 3364, 1715, 1237, and 806 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.49 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 2.34 (s, 3H, CH_3-Ar), 4.46 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.19 (d, 2H, ^3J=8.6 Hz, aryl H_m), 7.54 (dd, 1H, ^3J=8.3, 4.3 Hz, H_3), 7.83 (s, 1H, H_5), 8.00 (d, 2H, ^3J=8.3 Hz, aryl H_o), 8.06 (dd, 1H, ^3J=8.3 Hz, ^4J=1.4 Hz, H_4), 8.81 (dd, 1H, ^3J=4.3 Hz, ^4J=1.3 Hz, H_2), 9.04 (s, 1H, NH); ^{13}C n.m.r. δ ($CDCl_3$): 14.23 (CH_3-CH_2O), 20.75 (CH_3-Ar), 61.34 (CH_2O), 113.20 (C_5), 118.72 (aryl C_o), 125.44 (C_3), 129.36 (aryl C_m), 130.69 (C_{4a}), 131.61 (aryl C_p), 135.23 (C_{8a}), 136.08 (C_4), 137.28 (aryl C_i), 140.89 (C_6), 150.00 (C_2), 152.15 (C_8), 165.84 (C=O); m/z (%): 307 (M^+, 36), 234 (20), 143 (29), 128 (38), 91 (47), 73 (100).

7c: 8-(4-Methoxyphenyl)amino, (24%), m.p. 127-128°C, as yellow prisms. (Found: C, 66.94; H, 5.21; N, 12.84. $C_{18}H_{17}N_3O_3$ requires: C, 66.86; H, 5.30; N, 13.00); i.r. (Nujol): 3382, 1715, 1234, and 829 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.48 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 3.81 (s, 3H, CH_3O-Ar), 4.46 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.95 (d, 2H, ^3J=9.0 Hz, aryl H_m), 7.55 (dd, 1H, ^3J=8.2, 4.3 Hz, H_3), 7.82 (s, 1H, H_5), 8.05 (m, 3H), 8.81 (dd, 1H, ^3J=4.3 Hz, ^4J=1.3 Hz, H_2), 9.00 (s, 1H, NH); ^{13}C n.m.r. δ ($CDCl_3$): 14.24 (CH_3-CH_2O), 55.46 (CH_3O-Ar), 61.34 (CH_2O), 113.03 (C_5), 114.13 (aryl C_o), 120.12 (aryl C_o), 125.45 (C_3), 130.70 (C_{4a}), 133.31 (aryl C_i), 135.25 (C_{8a}), 136.08 (C_4), 140.91 (C_6), 149.97 (C_2), 152.15 (C_8), 154.96 (aryl C_p) 165.84 (C=O); m/z (%): 323 (M^+, 100), 250 (16), 234 (100), 143 (38).

8a: 1-Phenylamino, (22%), m.p. 181-182°C, as yellow prisms. (Found: C, 69.48; H, 5.04; N, 14.21. $C_{17}H_{15}N_3O_2$ requires: C, 69.61; H, 5.15; N, 14.33); i.r. (Nujol): 3412, 1694, 1254, and 754 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.47 (t, 3H, ^3J=7.1 Hz, CH_3), 4.46 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.06 (t, 1H, ^3J=7.3 Hz, phenyl H_p), 7.35 (m, 3H), 7.78 (d, 1H, ^3J=5.8 Hz, H_8), 7.91 (d, 2H, ^3J=8.0 Hz, phenyl H_o), 8.05 (s, 1H, H_4), 8.71 (d, 1H, ^3J=5.8 Hz, H_7), 9.25 (s, 1H, H_5); ^{13}C n.m.r. δ ($CDCl_3$): 14.23 (CH_3), 61.61 (CH_2O), 113.89 (C_4), 114.47 (C_8), 119.70 (phenyl C_o), 123.21 (C_{4a}), 123.21 (phenyl C_p), 128.96 (phenyl C_m), 131.53 (C_{8a}), 139.63 (phenyl C_i), 141.42 (C_3), 146.42 (C_7), 150.90 (C_1), 152.96 (C_5), 165.38 (C=O); m/z (%): 293 (M^+, 42), 220 (32), 219 (100), 77 (59).

8b: **1-(4-Methylphenyl)amino**, (25%), m.p. 182-183°C, as yellow prisms. (Found: C, 70.12; H, 5.43; N, 13.51. $C_{18}H_{17}N_3O_2$ requires: C, 70.34; H, 5.57; N, 13.67); i.r. (Nujol): 3418, 1694, 1252, and 812 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.46 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 2.26 (s, 3H, CH_3-Ar), 4.44 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.07 (d, 2H, ^3J=8.3 Hz, aryl H_m), 7.19 (s, 1H, NH), 7.78 (m, 3H), 7.98 (s, 1H, H_4), 8.61 (d, 1H, ^3J=5.8 Hz, H_7), 9.18 (s, 1H, H_5); ^{13}C n.m.r. δ ($CDCl_3$): 14.18 (CH_3-CH_2O), 20.67 (CH_3-Ar), 61.48 (CH_2O), 113.35 (C_4), 114.72 (C_8), 119.92 (aryl C_o), 123.18 (C_{8a}), 129.55 (aryl C_m), 131.42 (C_{4a}), 132.63 (aryl C_p), 137.05 (aryl C_i), 141.50 (C_3), 146.13 (C_7), 151.12 (C_1), 152.63 (C_5), 165.46 (C=O); m/z (%): 307 (M^+, 63), 234 (27), 233 (100), 91 (89).

8c: **1-(4-Methoxyphenyl)amino**, (26%), m.p. 127-128°C, as yellow prisms. (Found: C, 66.85; H, 5.24; N, 12.91. $C_{18}H_{17}N_3O_3$ requires: C, 66.86; H, 5.30; N, 13.00); i.r. (Nujol): 3414, 1696, 1237, and 839 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.46 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 3.78 (s, 3H, CH_3O-Ar), 4.45 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.87 (d, 2H, ^3J=9.0 Hz, aryl H_m), 7.27 (s, 1H, NH), 7.77 (m, 3H), 8.01 (s, 1H, H_4), 8.68 (d, 1H, ^3J=5.8 Hz, H_7), 9.23 (s, 1H, H_5); ^{13}C n.m.r. δ ($CDCl_3$): 14.26 (CH_3-CH_2O), 55.46 (CH_3O-Ar), 61.57 (CH_2O), 113.37 (C_4), 114.16 (aryl C_m), 114.61 (C_8), 121.70 (aryl C_o), 123.15 (C_{4a}), 131.57 (C_{8a}), 132.85 (aryl C_i), 141.50 (C_3), 146.30 (C_7), 151.27 (C_1), 152.85 (C_5), 155.81 (aryl C_p), 165.46 (C=O); m/z (%): 323 (M^+, 60), 250 (17), 206 (65), 179 (34), 116 (41), 92 (98), 64 (100).

General Procedure for the Preparation of 1-Arylimino-3-ethoxycarbonyl-1H-pyrido[1,2-c]pyrimidines 11.

To a solution of the iminophosphorane **10** (0.25 g, 0.55 mmol) in dry dichloromethane (10 ml) was added the appropriate isocyanate (0.55 mmol). The mixture was stirred at room temperature for 2h, then the solvent was removed and the residual material was chromatographed on a silica gel column, eluting with ethyl acetate/n-hexane (2:1) to give **11** which was further recrystallized from ethanol.

11a: **1-Phenylimino**, (90%), m.p. 99-100°C, as red prisms. (Found: C, 69.48; H, 5.06; N, 14.17. $C_{17}H_{15}N_3O_2$ requires: C, 69.61; H, 5.15; N, 14.33); i.r. (Nujol): 1711, 1613, 1233, and 791 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.30 (t, 3H, ^3J=7.1 Hz, CH_3), 4.27 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.74 (s, 1H, H_4), 6.91 (t, 1H, ^3J=7.1 Hz, phenyl H_p), 7.01 (t, 1H, ^3J=6.9 Hz, H_7), 7.22 (m, 3H), 7.05 (t, 1H, ^3J=6.9 Hz, H_7), 7.22 (m, 3H, 7.50 (m, 3H), 9.44 (d, 1H, ^3J=7.1 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 13.96 (CH_3), 61.81 (CH_2O), 96.52 (C_4), 118.35 (C_7), 122.33 (phenyl C_p), 123.70 (phenyl C_o), 124.54 (C_5), 128.24 (phenyl C_m), 131.23 (C_8), 136.87 (C_6), 146.31 (C_1), 147.62 (phenyl C_i), 148.68 (C_{4a}), 151.79 (C_3), 164.64 (C=O); m/z (%): 293 (M^+, 41), 264 (100), 117 (39), 103 (18), 91 (12), 77 (22).

11b: **1-(4-Methylphenyl)imino**, (82%), m.p. 132-133°C, as red prisms. (Found: C, 70.22; H, 5.44; N, 13.49. $C_{18}H_{17}N_3O_2$ requires: C, 70.34; H, 5.57; N, 13.67); i.r. (Nujol): 1738, 1615, 1225, and 787 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.31 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 2.23 (s, 3H, CH_3-Ar), 4.27 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.69 (s, 1H, H_4), 7.03 (m, 3H), 7.21 (d, 1H, ^3J=8.5 Hz, H_5), 7.43 (d, 2H, ^3J=8.4 Hz, aryl H_o), 7.49 (t, 1H, ^3J=8.0 Hz, H_6), 9.42 (d, 1H, ^3J=7.1 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 13.99 (CH_3-CH_2O), 20.86 (CH_3-Ar), 61.79 (CH_2O), 96.13 (C_4), 118.12 (C_7), 123.55 (aryl C_o), 124.47 (C_5), 128.85 (aryl C_m), 131.27 (C_8), 131.65 (aryl C_p), 136.74 (C_6), 144.89 (aryl C_i), 146.11 (C_1), 148.78 (C_{4a}), 151.85 (C_3), 164.75 (C=O); m/z (%): 307 (M^+, 52), 278 (100), 234 (19), 118 (62), 117 (32), 91 (27).

11c: **1-(4-Fluorophenyl)imino**, (87%), m.p. 126-127°C, as red prisms. (Found: C, 65.46; H, 4.41 N, 13.35. $C_{17}H_{14}FN_3O_2$ requires: C, 65.59; H, 4.53; N, 13.50; i.r. (Nujol): 1738, 1613 1227, and 789 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.40 (t, 3H, ^3J=7.1 Hz, CH_3), 4.37 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.83 (s, 1H, H_4), 6,98 (t, 2H, ^3J=8.8 Hz, aryl H_m), 7.16

(dt, 1H, ^3J=7.0 Hz, ^4J=1.2 Hz, H_7), 7.34 (d, 1H, ^3J=8.5 Hz, H_5), 7.61 (m, 3H), 9.51 (d, 1H, ^3J=7.1 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 13.98 (CH_3), 61.87 (CH_2O), 96.64 (C_4), 114.59 (aryl C_m, $^2J_{F-C}$=21.9 Hz), 118.42 (C_7), 124.61 (C_5), 124.94 (aryl C_o, $^3J_{F-C}$=7.6 Hz), 131.24 (C_8), 136.92 (C_6), 143.67 (aryl C_i, $^4J_{F-C}$=2.6 Hz), 146.27 (C_1), 148.71 (C_{4a}), 151.65 (C_3), 158.50 (aryl Cp, $^1J_{F-C}$=240.3 Hz), 164.55 (C=O); m/z (%): 311 (M^+, 53), 282 (55), 238 (23), 121 (19), 118 (100), 109 (5), 95 (9).

11d: **1-(4-Methoxyphenyl)imino**, (90%), m.p. 146-147°C, as red prisms. (Found: C, 66.70; H, 5.16; N, 12.89. $C_{18}H_{17}N_3O_3$ requires: C, 66.86; H, 5.30; N, 13.00); i.r. (Nujol): 1738, 1613, 1221, and 839 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.40 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 3.79 (s, 3H, CH_3O-Ar), 4.37 (q, 2H, ^3J=7.1 Hz, CH_2O), 6.75 (s, 1H, H4), 6.88 (d, 2H, ^3J=8.9 Hz, aryl H_m), 7.11 (dt, 1H, ^3J=7.0 Hz, ^4J=1.4 Hz, H_7), 7.28 (d, 1H, ^3J=8.1 Hz, H_5), 7.57 (t, 1H, ^3J=7.1 Hz, H_6), 7.63 (d, 2H, ^3J=8.9 Hz, aryl H_o), 9.49 (d, 1H, ^3J=7.0 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 13.98 (CH_3-CH_2O), 55.33 (CH_3O-Ar), 61.75 (CH_2O), 95.93 (C_4), 113.54 (aryl C_m), 118.07 (C_7), 124.43 (C_5), 124.73 (aryl C_o), 131.23 (C_8), 136.74 (C_6), 140.79 (aryl C_i), 145.66 (C_1), 148.82 (C_{4a}), 151.68 (C_3), 155.10 (aryl C_p), 164.69 (C=O); m/z (%): 323 (M^+, 100),308 (52), 294 (26), 118 (48).

General Procedure for the Preparation of Ethyl 1-Oxo(thio)-1H-pyrido[1,2-c]pyrimidine-3-carboxylates 12 and 13 .

A mixture of iminophosphorane **10** (0.25 g, 0.55 mmol) and excess of solid carbon dioxide or carbon disulfide in dry toluene (15 ml) was heated in a sealed glass tube at 120°C for 2h. After cooling, the separated solid was collected and recrystallized from toluene to give **12** or **13**.

12: **Ethyl 1-oxo-1H-pyrido[1,2-c]pyrimidine-3-carboxylate**, (83%), m.p. 198-200°C, as yellow prisms. (Found: C, 60.71; H, 4.51; N, 12.66. $C_{11}H_{10}N_2O_3$ requires: C, 60.55; H, 4.62; N, 12.84); i.r. (Nujol): 1717, 1674, 1231, and 779 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 1.45 (t, 3H, ^3J=7.1 Hz, CH_3), 4.46 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.46 (s, 1H, H_4), 7.60 (dt, 1H, ^3J=6.9 Hz, ^4J=1.4 Hz, H_7), 7.87 (d, 1H, ^3J=8.7 Hz, H_5), 8.09 (dt, 1H, ^3J=7.4 Hz, ^4J=1.4 Hz, H_6), 9.33 (d, 1H, ^3J=6.9 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 13.91 (CH_3), 62.10 (CH_2O), 100.56 (C_4), 120.15 (C_7), 125.42 (C_5), 130.96 (C_8), 138.28 (C_6), 148.88 (C_{4a}), 150.87 (C_1), 153.31 (C_3), 164.10 (C=O); m/z (%): 218 (M^+, 17),146 (100), 118 (70).

13: **Ethyl 1-thioxo-1H-pyrido[1,2-c]pyrimidine-3-carboxylate**, (93%), m.p. 219-220°C, as yellow prisms. (Found: C, 56.28; H, 4.16; N, 11.78. $C_{11}H_{10}N_2O_2S$ requires: C, 56.40; H, 4.30; N, 11.96); i.r. (Nujol): 17.36, 1622, 1566, 1229, and 799 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.39 (t, 3H, ^3J=7.1 Hz, CH_3), 4.41 (q, 2H, ^3J=7.1 Hz, CH_2O), 8.00 (dt, 1H, ^3J=6.5 Hz, ^4J=2.3 Hz, H_7), 8.08 (s, 1H, H_4), 8.37 (m, 2H, H_5, H_6), 10.48 (d, 1H, ^3J=7.0 Hz, H_8); ^{13}C n.m.r. δ (DMSO): 14.06 (CH_3), 61.86 (CH_2O), 108.37 (C_4), 123.85 (C_7), 127.66 (C_5), 135.10 (C_8), 139.64 (C_6), 145.15 (C_3), 147.19 (C_{4a}), 163.50 (C=O), 173.26 (C_1); m/z (%): 234 (M^+, 35), 205 (20), 161 (91), 91 (30).

General Procedure for the Preparation of Ethyl 8-Arylpyrido[1,2-c]pyrimidinium-3-carboxylate Chlorides 14 .

To a solution of the iminophosphorane **10** (0.25 g, 0.55 mmol) in dry dichloromethane (15 ml) was added the appropiate acyl chlorides (0.55 mmol). The mixture was stirred at room temperature for 1h and the separated solid was collected by filtration, air-dried, and recrystallized from ethanol/diethyl ether (1:6) to give **14**.

14a: 1-Phenyl, (92%), m.p. 221-223°C (dec.), as white prisms. (Found: C, 64.80; H, 4.59; N, 8.72. $C_{17}H_{15}ClN_2O_2$ requires: C, 64.87; H, 4.80; N, 8.90); i.r. (Nujol): 1742, 1636, 1254, and 762 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.40 (t, 3H, ^3J=7.1 Hz, CH_3), 4.50 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.76 (m, 3H), 7.93 (d, 2H, ^3J=7.3 Hz, phenyl H_o), 8.30 (t, 1H, ^3J=6.8 Hz, H_7), 8.89 (t, 1H, ^3J=7.7 Hz, H_6), 9.11 (d, 1H, ^3J=8.2 Hz, H_5), 9.28 (d, 1H, ^3J=6.8 Hz, H_8), 9.38 (s, 1H, H_4); ^{13}C n.m.r. δ (DMSO): 14.02 (CH_3), 62.72 (CH_2O), 121.19 (C_4), 127.09 (C_7), 128.43 (C_5), 129.28 (phenyl C_m), 129.81 (phenyl C_o), 130.87 (phenyl C_i), 131.95 (phenyl C_p), 135.74 (C_8), 143.33 (C_6), 143.99 (C_3), 146.40 (C_{4a}), 154.63 (C_1), 162.05 (C=O); m/z (%): 279 (M^+, 2), 250 (18), 118 (26), 105 (100), 77 (32).

14b: 1-(4-Methylphenyl), (94%), m.p. 218-220°C (dec.), as white prisms. (Found: C, 65.60; H, 5.04; N, 8.40. $C_{18}H_{17}ClN_2O_2$ requires: C, 65.75; H, 5.21; N, 8.52; i.r. (Nujol): 1742, 1640, 1244, 1157, and 828 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.39 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 2.89 (s, 3H, CH_3-Ar), 4.49 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.55 (d, 2H, ^3J=7.9 Hz, aryl H_m), 7.83 (d, 2H, ^3J=7.9 Hz, aryl H_o), 8.30 (t, 1H, ^3J=7.0 Hz, H_7), 8.87 (t, 1H, ^3J=7.8 Hz, H_6), 9.11 (d, 1H, ^3J=8.2 Hz, H_5), 9.30 (d, 1H, ^3J=6.9 Hz, H_8), 9.35 (s, 1H, H_4); ^{13}C n.m.r. δ (DMSO): 13.99 (CH_3-CH_2O), 21.13 (CH_3-Ar), 62.63 (CH_2O), 120.93 (C_4), 126.98 (C_7), 128.04 (aryl C_i), 128.41 (C_5), 129.69, 129.84, 135.64 (C_8), 142.07 (aryl C_p), 143.18 (C_6), 143.93 (C_3), 146.46 (C_{4a}), 154.76 (C_1), 162.04 (C=O); m/z (%): 293 (M^+, 1), 264 (13), 119 (100), 91 (44).

14c: 1-(4-Chlorophenyl), (90%), m.p. 228-229°C (dec.), as white prisms. (Found: C, 58.28; H, 3.87; N, 7.89. $C_{17}H_{14}Cl_2N_2O_2$ requires: C, 58.47; H, 4.04 N, 8.02; i.r. (Nujol): 1740, 1640, 1244, and 833 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.40 (t, 3H, ^3J=7.1 Hz, CH_3), 4.50 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.84 (d, 2H, ^3J=8.3 Hz, aryl H_m), 7.96 (d, 2H, ^3J=8.3 Hz, aryl H_o), 8.28 (t, 1H, ^3J=7.0 Hz, H_7), 8.89 (t, 1H, ^3J=7.8 Hz, H_6), 9.09 (d, 1H, ^3J=8.2 Hz, H_5), 9.32 (d, 1H, ^3J=6.8 Hz, H_8), 9.38 (s, 1H, H_4); ^{13}C n.m.r. δ (DMSO): 14.06 (CH_3), 62.79 (CH_2O), 121.92 (C_4), 127.15 (C_7), 128.44 (C_5), 129.52 (aryl C_m), 129.77 (aryl C_i), 131.88 (aryl C_o), 136.04 (C_8), 136.86 (aryl C_p), 143.50 (C_6), 143.93 (C_3), 146.32 (C_{4a}), 153.85 (C_1), 162.01 (C=O); m/z (%): 315 (M^++1, 1), 313 (M^+, 3), 139 (100), 111 (43).

14d: 1-(4-Methoxyphenyl), (84%), m.p. 228-229°C (dec.), as white prisms. (Found: C, 62.81; H, 4.80; N, 7.96. $C_{18}H_{17}ClN_2O_3$ requires: C, 62.70; H, 4.97 N, 8.12; i.r. (Nujol): 1730, 1638, 1262, and 843 cm^{-1}; ^1H n.m.r. δ (DMSO): 1.40 (t, 3H, ^3J=7.1 Hz, CH_3-CH_2O), 3.92 (s, 3H, CH_3O-Ar), 4.50 (q, 2H, ^3J=7.1 Hz, CH_2O), 7.29 (d, 2H, ^3J=8.5 Hz, aryl H_m), 7.90 (d, 2H, ^3J=8.5 Hz, aryl H_o), 8.30 (t, 1H, ^3J=7.2 Hz, H_7), 8.87 (t, 1H, ^3J=7.7 Hz, H_6), 9.10 (d, 1H, ^3J=8.3 Hz, H_5), 9.32 (s, 1H, H_4), 9.38 (d, 1H, ^3J=6.9 Hz, H_8); ^{13}C n.m.r. δ (DMSO): 14.01 (CH_3-CH_2O), 55.69 (CH_3O-Ar), 62.66 (CH_2O), 114.70 (aryl C_m), 120.49 (C_4), 122.86 (aryl C_i), 126.88 (C_7), 128.35 (C_5), 131.97 (aryl C_o), 135.60 (C_8), 143.14 (C_3), 144.02 (C_6), 146.62 (C_{4a}), 154.72 (C_1), 162.03 (C=O), 162.12 (aryl C_p); m/z (%): 309 (M^+, 1), 280 (13), 135 (100).

Preparation of 2-(o-Nitrophenyl)pyridine 19.

To a solution of o-nitroiodobenzene (1 g, 4.0 mmol) in dry tetrahydrofuran (25 ml) were added $PdCl_2(PPh_3)_2$ (0.14 g, 0.2 mmol) and 2-tributylstannylpyridine **18** (1.62 g, 4.4 mmol). The reaction mixture was heated at 110°C for 24h. After cooling, diethyl ether was added and the resulting suspension was filtered on Celite. The filtrate was washed with water (4x25 ml) and the combined organic layers was dried over anhydrous sodium sulfate and filtered. The solvent was removed under reduced pressure and the residual material was chromatographed on a silica gel column, eluting with ethyl acetate/n-hexane (4:3) to give a yellow oil which was recrystallized from diethyl ether

to give **19** in 75% yield, m.p. 59-60°C (lit.[12] m.p. 58-59°C); i.r. (Nujol): 1589, 1532, 1362, and 744 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 7.29 (d, 1H, ^3J=4.7 Hz, H_5), 7.46 (d, 1H, ^3J=7.8 Hz, aryl H_6), 7.60 (m, 3H), 7.78 (td, 1H, ^3J=7.7 Hz, ^4J=1.7 Hz, H_4), 7.87 (d, 1H, ^3J=7.9 Hz, aryl H_3), 8.63 (d, 1H, ^3J=4.7 Hz, H_6); ^{13}C n.m.r. δ ($CDCl_3$): 122.55, 122.80, 124.25, 129.11, 131.12, 132.30, 135.17 (aryl C_1), 136.77 (C_4), 149.18 (aryl C_2), 149.55 (C_6), 155.35 (C_1); m/z (%): 200 (M^+, 17), 170 (83), 127 (100).

Preparation of 2-(o-Aminophenyl)pyridine 20.

To a solution of 2(o-nitrophenyl)pyridine **19** (0.5 g, 2.5 mmol) in ethanol (15 ml), was added a solution of $CuSO_4$ (0.04 g, 0.25 g) in water (2 ml). The resultant suspension was cooled at 0°C and sodium borohydride (0.47 g, 12.5 mmol) was slowly added, then stirred for 3h. To the reaction mixture ethyl acetate (15 ml) was added, then washed with water (3x15 ml). The combined organic layer was dried over anhydrous sodium sulfate, filtered and the solvent was removed. The crude product was chromatographed on a silica gel colum, eluting with ethyl acetate/ n-hexane (1:1) to give **20** as a pale yellow oil (lit.[12] pale yellow oil). i.r. (Nujol): 3445, 1613, and 750 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 5.39 (s, 2H, NH_2), 6.76 (m, 2H), 7.17 (m, 2H), 7.49 (dd, 1H, ^3J=7.6 Hz, ^4J=1.1 Hz), 7.68 (m, 2H), 8.58 (d, 1H, ^3J=4.6 Hz, H_6); ^{13}C n.m.r. δ ($CDCl_3$): 117.13 (aryl C_3), 117.55 (aryl C_5), 120.87, 122.14, 129.33, 129.82, 130.90 (aryl C_1), 136.82 (C_4), 146.46 (aryl C_2), 147.77 (C_6), 159.36 (C_1); m/z (%): 170 (M^+, 48), 169 (100).

Preparation of 2-(o-Azidophenyl)pyridine 21.

A mixture of 2-(o-aminophenyl)pyridine **20** (0.5 g, 2.94 mmol) concentrated hydrochloric acid (5 ml) was cooled at 0°C, then a solution of sodium nitrite (0.32 g, 4.6 mmol) in water (5 ml) was added. The resultant solution was stirred at 0°C for 1h, after which a mixture of sodium azide (0.3 g, 4.6 mmol), sodium acetate (2 g, 24.4 mmol) in water (10 ml) was added. After stirring at this temperature for 1h the solution was allowed to warm at room temperature, then 30% aqueous solution of ammonium hydroxide was added until pH=7. The solution was extracted with diethyl ether (3x15 ml) and the combined organic layer was dried over anhydrous sodium sulfate and filtered. The solvent was removed under reduced pressure to give **21** as a yellow oil in 92% yield. (Found: C, 67.16; H, 3.90; N, 28.76. $C_{11}H_8N_4$ requires: C, 67.34; H, 4.11; N, 28.55); i.r. (Nujol): 2128, 2095, and 750 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 7.23 (m, 3H), 7.42 (td, 1H, ^3J=7.7 Hz, ^4J=1.8 Hz), 7.70 (m, 3H), 8.70 (dt, 1H, ^3J=4.9 Hz, ^4J=1.1 Hz, H_6); ^{13}C n.m.r. δ ($CDCl_3$): 118.77, 122.07, 124.75, 124.97, 129.76, 131.40, 132.17 (q), 135.77, 137.15 (q), 149.41, 155.68 (q); m/z (%): 196 (M^+, 1), 168 (100), 114 (31), 78 (34).

General Procedure for the Preparation of Anhydro 6-Arylaminopyrido[1,2-c]quinazolin-7-ium Hydroxides 23.

To a solution of the iminophosphorane **22** (0.25 g, 0.6 mmol) in dry dichloromethane (10 ml) was added the appropriate isocyanate (0.6 mmol). The deep red solution was stirred at room temperature for 2h, then the solvent is removed under reduced pressure. The crude material was chromatographed on a silica gel column, eluting with acetone to give **23** which was further recrystallized from dichloromethane/diethyl ether/n-hexane (1:9:2).

23 a: 6-Phenylamino, (88%), m.p. 126-127°C, as red prisms. (Found: C, 78.46; H, 4.95; N, 7.40. $C_{18}H_{13}N_3.C_{18}H_{15}OP$ requires: C, 78.67; H, 5.14; N, 7.65); i.r. (Nujol): 1622, 1582, 1449, and 723 cm^{-1}; ^1H n.m.r. δ

($CDCl_3$): 6.89 (t, 1H, ^3J=7.5 Hz, H_2), 6.97 (t, 1H, ^3J=7.4 Hz, phenyl H_p), 7.29 (d, 1H, ^3J=8.1 Hz, H_4), 7.33 (t, 2H, ^3J=7.8 Hz, phenyl H_m), 7.47 (m, 13H), 7.66 (m, 6H), 7.83 (d, 1H, ^3J=8.7 Hz, H_1), 8.01 (td, 1H, ^3J=7.8 Hz, ^4J=1.2 Hz, H_{10}), 8.29 (d, 1H, ^3J=8.4 Hz, H_{11}), 10.28 (d, 1H, ^3J=6.6 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 110.44 (C_{11b}), 119.82 (C_2), 119.95 (C_{11}), 120.48 (C_9), 121.23 (phenyl C_p), 123.36 (C_1), 123.52 (phenyl C_o), 125.66 (C_4), 128.38 (phenyl C_m), 128.39 (phenyl-P C_m, $^3J_{P\text{-}C}$=12.0 Hz),131.76 (phenyl-P C_p, $^4J_{P\text{-}C}$=3.5 Hz), 131.93 (phenyl-P C_o, $^2J_{P\text{-}C}$=10.0 Hz), 132.38 (phenyl-P C_i, $^1J_{P\text{-}C}$=103.2 Hz), 134.21 (C_8), 134.65 (C_3), 139.55 (C_{10}), 144.47 (C_6), 147.03 (C_{11a}), 148.77 (phenyl C_i), 150.09 (C_{4a}); m/z (%): 271 (M^+, 50), 270 (100).

23 b: **6-(4-Methylphenyl)amino**, (90%), m.p. 125-126°C, as red prisms. (Found: C, 78.99; H, 5.52; N, 7.32. $C_{19}H_{15}N_3.C_{18}H_{15}OP$ requires: C, 78.85; H, 5.36; N, 7.46); i.r. (Nujol): 1636, and 1456 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 2.33 (s, 3H, CH_3), 6.99 (t, 1H, ^3J=7.5 Hz, H_2), 7.14 (d, 2H, ^3J=8.4 Hz, aryl H_m), 7.35 (d, 1H, ^3J=8.4 Hz, H_4), 7.51 (m, 13H), 7.67 (m, 6H), 7.93 (d, 1H, ^3J=8.7 Hz, H_1), 8.14 (td, 1H, ^3J=7.8 Hz, ^4J=0.6 Hz, H_{10}), 8.42 (d, 1H, ^3J=8.4 Hz, H_{11}), 10.38 (d, 1H, ^3J=6.9 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 20.86 (CH_3), 110.19 (C_{11b}), 119.42 (C_2), 119.77 (C_{11}), 120.29 (C_9), 123.32 (phenyl C_o), 123.32 (C_1), 125.44 (C_4), 128.34 (phenyl-P C_m, $^3J_{P\text{-}C}$=12.1 Hz), 128.92 (phenyl C_m), 130.25 (phenyl C_p), 131.58 (phenyl-P C_p, $^4J_{P\text{-}C}$=2.9 Hz), 131.88 (phenyl-P C_o, $^2J_{P\text{-}C}$=9.9 Hz), 132.38 (phenyl-P C_i, $^1J_{P\text{-}C}$=104.2 Hz), 133.98 (C_8), 134.47 (C_3), 139.33 (C_{10}), 144.33 (C_6), 146.20 (phenyl C_i), 146.90 (C_{11a}), 150.17 (C_{4a}); m/z (%): 285 (M^+, 60), 284 (100).

23 c: **6-(4-Fluorophenyl)amino**, (88%), m.p. 110-111°C, as red prisms. (Found: C, 76.00; H, 4.95; N, 7.23. $C_{18}H_{12}FN_3.C_{18}H_{15}OP$ requires: C, 76.18; H, 4.79; N, 7.40); i.r. (Nujol): 1634, and 825 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 6.86 (t, 1H, ^3J=7.2 Hz, H_2), 6.99 (t, 2H, ^3J=8.8 Hz, aryl H_m), 7.23 (d, 1H, ^3J=8.3 Hz, H_4), 7.49 (m, 13H), 7.66 (m, 6H), 7.78 (d, 1H, ^3J=8.3 Hz, H_1), 7.97 (t, 1H, ^3J=7.8 Hz, H_{10}), 8.23 (d, 1H, ^3J=8.5 Hz, H_{11}), 10.19 (d, 1H, ^3J=6.8 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 110.37 (C_{11b}), 114.58 (aryl Cm, $^2J_{F\text{-}C}$=21.6 Hz), 119.78 (C_2), 119.87 (C_{11}), 120.42 (C_9), 123.34 (C_1), 124.51 (aryl C_o, $^3J_{F\text{-}C}$=7.5 Hz), 125.41 (C_4), 128.36 (phenyl-P C_m, $^3J_{P\text{-}C}$=12.1 Hz),131.81 (phenyl-P C_p, $^4J_{P\text{-}C}$=2.3 Hz), 131.89 (phenyl-P C_o, $^2J_{P\text{-}C}$=10.4 Hz), 132.37 (phenyl-P C_i, $^1J_{P\text{-}C}$=103.2 Hz), 134.02 (C_8), 134.61 (C_3), 139.48 (C_{10}), 144.31 (C_6), 144.85 (aryl C_i, $^4J_{F\text{-}C}$=2.5 Hz), 146.92 (C_{11a}), 149.88 (C_{4a}), 157.73 (aryl Cp, $^1J_{F\text{-}C}$=238.7 Hz); m/z (%): 289 (M^+, 67), 288 (100).

23 d: **6-(4-Methoxyphenyl)amino**, (92%), m.p. 141-142°C, as red prisms. (Found: C, 75.91; H, 4.86; N, 13.79. $C_{19}H_{15}N_3O$ requires: C, 75.73; H, 5.02; N, 13.94); i.r. (Nujol): 1636, 1451, and 835 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 3.81 (s, 3H, CH_3O), 6.83 (t, 1H, ^3J=8.0 Hz, H_2), 6.90 (d, 2H, ^3J=8.9 Hz, aryl H_m), 7.22 (d, 1H, ^3J=8.3 Hz, H_4), 7.41 (m, 2H, H_9, H_3), 7.64 (d, 2H, ^3J=8.9 Hz, aryl H_o), 7.75 (d, 1H, ^3J=8.4 Hz, H_1), 7.94 (t, 1H, ^3J=7.8 Hz, H_{10}), 8.19 (d, 1H, ^3J=8.6 Hz, H_{11}), 10.20 (d, 1H, ^3J=6.9 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 55.48 (CH_3O), 110.24 (C_{11b}), 113.75 (aryl C_m), 119.47 (C_2), 119.83 (C_{11}), 120.35 (C_9), 123.39 (C_1), 124.36 (aryl C_o), 125.49 (C_4), 134.11 (C_8), 134.60 (C_3), 139.41 (C_{10}), 142.06 (aryl C_i), 144.15 (C_6), 147.05 (C_{11a}), 150.26 (C_{4a}), 154.31 (aryl C_p); m/z (%): 301 (M^+, 64), 286 (94), 127 (100).

Preparation of Anhydro 6-Hydroxypyrido[1,2-c]quinazolin-7-ium Hydroxide 24.

A mixture of iminophosphorane **22** (0.25 g, 0.6 mmol) and excess of solid carbon dioxide in dry toluene (15 ml) was heated in a sealed tube at 70°C for 12h. After cooling, the separated solid was collected by filtration and recrystallized from toluene to give **24** as yellow prisms in 82% yield, m.p. 214-216°C. (Found: C, 73.60; H, 4.23;

N, 14.08. $C_{12}H_8N_2O$ requires: C, 73.46; H, 4.11; N, 14.28); i.r. (Nujol): 1699 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 7.22 (t, 1H, ^3J=7.6 Hz, H2), 7.36 (d, 1H, ^3J=8.4 Hz, H_4), 7.66 (t, 1H, ^3J=7.6 Hz, H_3), 8.00 (t, 1H, ^3J=6.9 Hz, H_9), 8.44 (d, 1H, ^3J=8.3 Hz, H_1), 8.55 (t, 1H, ^3J=7.8 Hz, H_{10}), 9.00 (d, 1H, ^3J=8.5 Hz, H_{11}), 9.66 (d, 1H, ^3J=6.6 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 111.89 (C_{11b}), 121.14 (C_2), 121.46 (C_{11}), 122.61 (C_9), 124.48 (C_1), 124.62 (C_4), 133.68 (C_8), 134.14 (C_3), 142.16 (C_{10}), 145.76 (C6), 147.58 (C11a), 148.86 (C4a); m/z (%): 196 (M^+, 42),168 (100).

Preparation of Anhydro 6-Mercaptopyrido[1,2-c]quinazolin-7-ium Hydroxide 25.

This compound was prepared as described above, using CS_2, by heating the reaction mixture at 110°C for 15h to give **25** as red prisms in 87% yield, m.p. 220-221°C. (Found: C, 67.73; H, 3.61; N, 13.05. $C_{12}H_8N_2S$ requires: C, 67.90; H, 3.80; N, 13.20); i.r. (Nujol): 1626, and 758 cm^{-1}; ^1H n.m.r. δ ($CDCl_3$): 7.49 (td, 1H, ^3J=7.7 Hz, ^4J=1.1 Hz, H2), 7.60 (d, 1H, ^3J=8.1 Hz, H_4), 7.83 (td, 1H, ^3J=7.7 Hz, ^4J=1.5 Hz, H_3), 8.17 (td, 1H, ^3J=6.9 Hz, ^4J=1.5 Hz, H_9), 8.64 (m, 2H), 9.17 (d, 1H, ^3J=8.4 Hz, H_{11}), 11.06 (d, 1H, ^3J=6.9 Hz, H_8); ^{13}C n.m.r. δ ($CDCl_3$): 114.63 (C_{11b}), 121.91 (C_{11}), 123.02 (C_9), 124.41 (C_1), 124.58 (C_2), 125.55 (C_4), 134.51 (C_3), 137.70 (C_8), 141.79 (C_{10}), 143.38 (C_{4a}), 145.02 (C_{11a}), 166.06 (C_6); m/z (%): 212 (M^+, 100),168 (99).

General Procedure for the Preparation of 6-Arylpyrido[1,2-c]quinazolinium Chlorides 26.

A mixture of the iminophosphorane **22** (0.25 g, 0.6 mmol) and the appropriate acyl chloride (0.6 mmol) in dry toluene (15 ml) was refluxed for 2h. After cooling, the separated solid was collected by filtration and recrystallized from ethanol/diethyl ether (1:3) to give **26.**

26 a: 1-Phenyl, (82%), m.p. 260-261°C (dec.), as colourless prisms. (Found: C, 73.74; H, 4.60; N, 9.42. $C_{18}H_{12}ClN_2$ requires: C, 73.85; H, 4.48; N, 9.57); i.r. (Nujol): 1640, 1140, and 772 cm^{-1}; ^1H n.m.r. δ (DMSO): 7.59 (t, 1H, ^3J=7.1 Hz, phenyl H_p), 7.75 (t, 2H, ^3J=7.2 Hz, phenyl H_m), 7.94 (d, 2H, ^3J=7.5 Hz, phenyl H_o), 8.14 (m, 1H, H_9), 8.25 (m, 3H), 8.97 (t, 1H, ^3J=7.8 Hz, H_{10}), 9.22 (d, 1H, ^3J=6.9 Hz, H_8), 9.34 (d, 1H, ^3J=8.4 Hz, H_1), 9.85 (d, 1H, ^3J=8.7 Hz, H_{11}); ^{13}C n.m.r. δ (DMSO): 118.84 (C_{11b}), 123.25 (C_{11}), 125.01, 125.62, 128.79, 129.25 (phenyl C_o), 129.80 (phenyl C_m), 131.10 (C_9), 131.39 (phenyl C_p), 131.67 (phenyl C_i), 136.13, 137.45 (C_8), 141.07 (C_{4a}), 144.70 (C_{10}), 145.56 (C_{11a}), 149.58 (C_6); m/z (%): 257 (M^+, 45), 180 (5), 154 (11), 127 (39), 105 (18), 77 (30).

26 b: 1-(4-Methylphenyl), (81%), m.p. 292-293°C (dec.), as colourless prisms. (Found: C, 74.51; H, 4.70; N, 9.01. $C_{19}H_{15}ClN_2$ requires: C, 74.39; H, 4.93; N, 9.13); i.r. (Nujol): 1636, 1304, and 824 cm^{-1}; ^1H n.m.r. δ (DMSO): 2.49 (s, 3H, CH_3-Ar), 7.55 (d, 2H, ^3J=8.1 Hz, aryl H_m), 7.82 (d, 2H, ^3J=8.1 Hz, aryl H_o), 8.12 (m, 1H, H_9), 8.23 (m, 3H), 8.96 (t, 1H, ^3J=8.0 Hz, H_{10}), 9.25 (d, 1H, ^3J=6.6 Hz, H_8), 9.31 (d, 1H, ^3J=8.1 Hz, H_1), 9.82 (d, 1H, ^3J=8.7 Hz, H_{11}); ^{13}C n.m.r. δ (DMSO): 21.15 (CH_3-Ar), 118.76 (C_{11b}), 123.20 (C_{11}), 124.91, 125.56, 128.83, 128.86 (aryl C_i), 129.72 (aryl C_o), 129.75 (aryl C_m), 130.98 (C_9), 136.08, 137.44 (C_8), 141.11 (C_{4a}), 141.32 (aryl C_p), 144.63 (C_{10}), 145.60 (C_{11a}), 149.72 (C_6); m/z (%): 271 (M^+, 100), 255 (5), 180 (4), 154 (13), 128 (35), 119 (10), 91 (20).

26 c: 1-(4-Fluorophenyl), (94%), m.p. 267-268°C (dec.), as colourless prisms. (Found: C, 69.71; H, 3.70; N, 8.92. $C_{18}H_{12}ClFN_2$ requires: C, 69.57; H, 3.89; N, 9.01); i.r. (Nujol): 1630, 1229, and 777 cm^{-1}; ^1H n.m.r. δ (DMSO): 7.61 (t, 2H, ^3J=8.9 Hz, aryl H_m), 8.00 (dd, 2H, ^3J=8.6 Hz, $^4J_{F-H}$=5.3 Hz, aryl H_o), 8.15 (m, 1H, H_9), 8.22 (t, 1H, ^3J=6.9 Hz), 8.28 (m, 2H), 8.97 (t, 1H, ^3J=7.7 Hz, H_{10}), 9.26 (d, 1H, ^3J=6.6 Hz, H_8), 9.32 (d, 1H, ^3J=8.7 Hz, H_1), 9.81 (d, 1H, ^3J=8.7 Hz, H_{11}); ^{13}C n.m.r. δ (DMSO): 116.49 (aryl C_m, $^2J_{F-C}$=22.2 Hz), 118.84 (C_{11b}), 123.12 (C_{11}), 124.99, 125.57,

128.20 (aryl C_i, $^2J_{F-C}$=3.0 Hz), 128.93, 131.19 (C_9), 135.59 (aryl C_o, $^3J_{F-C}$=9.1 Hz), 136.18, 137.67 (C_8), 141.04 (C_{4a}), 144.75 (C_{10}), 145.52 (C_{11a}), 148.90 (C_6), 163.60 (aryl Cp, $^1J_{F-C}$=249.5 Hz); m/z (%): 275 (M^+, 94), 180 (7), 179 (36), 154 (16), 127 (100), 123 (12), 95 (21).

26 d: **1-(4-Methoxyphenyl)**, (91%), m.p. 269-270°C (dec.), as colourless prisms. (Found: C, 70.56; H, 4.63; N, 8.48. $C_{19}H_{15}ClN_2O$ requires: C, 70.70; H, 4.68; N, 8.68); i.r. (Nujol): 1636, 1231, and 721 cm^{-1}; ^1H n.m.r. δ (DMSO): 3.92 (s, 3H, CH_3O-Ar), 7.30 (d, 2H, ^3J=8.7 Hz, aryl H_m), 7.87 (d, 2H, ^3J=8.7 Hz, aryl H_o), 8.11 (m, 1H, H_9), 8.25 (m, 3H), 8.95 (t, 1H, ^3J=7.8 Hz, H_{10}), 9.31 (m, 2H), 9.79 (d, 1H, ^3J=8.7 Hz, H_{11}); ^{13}C n.m.r. δ (DMSO): 55.63 (CH_3O-Ar), 114.66 (aryl C_m), 118.68 (C_{11b}), 123.16 (C_{11}), 123.68 (aryl C_i), 124.88, 125.53, 128.85, 130.89 (C_9), 131.71 (aryl C_o), 136.10, 137.53 (C_8), 141.20 (C_{4a}), 144.63 (C_{10}), 145.70 (C_{11a}), 149.70 (C_6), 161.44 (aryl C_p); m/z (%): 288 (M^+, 15), 154 (20), 133 (15), 127 (100).

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REFERENCES

1.- Paudler, W.W.; Sheets, R.M. *Adv. Heterocyclic Chem.*, **1983**, 33, 147.

2.- Lowe, P.A. in *"Comprehensive Heterocyclic Chemistry"*, Ed. A.R. Katritsky, C.W. Rees, Pergamon Press **1984**, vol. 2, p. 581.

3.- Molina, P.; Fresneda, P.M.; Hurtado, F. *Synthesis*, **1987**, 45; Molina, P.; Fresneda, P.M. *J. Chem. Soc. Perkin Trans 1*, **1988**, 1819; Molina, P.; Aller, E.; Lorenzo, A.; *Tetrahedron*, **1991**, 47, 6737.

4.- Molina, P.; Tarraga, A.; Lidon, M.J. *J. Chem. Soc. Perkin Trans 1*, **1990**, 1727; Molina, P.; Alajarin, M.; Vidal, A. *J. Org. Chem.*, **1990**, 55, 6140; Molina, P.; Fresneda, P.M.; Almendros, P. *Tetrahedron*, **1991**, 47, 4175.

5.- Rosen, B.I.; Weber, W.P. *J. Org. Chem.*, **1977**, 42, 47; Valkovik, P.V. Conger, J.L.; Castiello, F.A.; Brodie, T.D.; Weber, W.P. *J. Am. Chem. Soc.*, **1975**, 97, 901.

6.- Hickey, D.M.B.; Moody, C.J.; Rees, C.W. *J. Chem. Soc. Perkin Trans 1*, **1986**, 1119.

7.- Molina, P.; Arques, A.; Vinader, M.V.; Becher, J.; Brondum, K. *Tetrahedron Lett.*, **1987**, 4451; *J. Org. Chem.*, **1988**, 53, 4654.

8.- Zbiral, E.; Bauer, E.; *Phosphorus*, **1972**, 2, 35.

9.- Peters, D.; Hörnfeldt, A.B.; Gronowitz, S. *J. Heterocyclic. Chem.*, **1990**, 27, 2165.

10.- Yoo, S.; Lee, S. *Synlett.*, **1990**, 419.

11.- Etter, M.C.; Baures, P.W. *J. Am. Chem. Soc.*, **1988**, 110, 639; Etter, M.C.; Urbañczyk-Lipkowska, Z.; Zia-Ebrahimi, M.; Panunto, T. W. *J. Am. Chem. Soc.*, **1990**, 112, 8415; Etter, M.C.; Reutzel, S.M. *J. Am. Chem. Soc.*, **1991**, 113, 2586; Llamas-Saiz, A.L.; Foces-Foces, L.C.;Elguero, J.; Molina, P.; Alajarin, M.; Vidal, A. *J. Chem. Soc. Chem. Commun.*, **1991**, 1694.

12.- Haworth, J.W.; Heilbron, I.N.; Hey, D.H. *J. Am. Chem. Soc.*, **1940**, 63, 349.