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## PREPARATION OF SOME NOVEL PYRIDONE DERIVATIVES [1]

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**Abstract.** 1-Amino-2- and -4-pyridone react with 4-pyrone to yield bipyridones. Some transformations of *N,N'*-bi-(2,6-lutidone) are described.

1-Amino-4, 6-diphenyl-2-pyridone reacts with  $\alpha$ -haloketones to give oxadiazinopyridinium salts. 2-Aminopyridines and 2-methyl-4,6-diphenylpyrylium salts give the corresponding pyridylpyridinium salts.

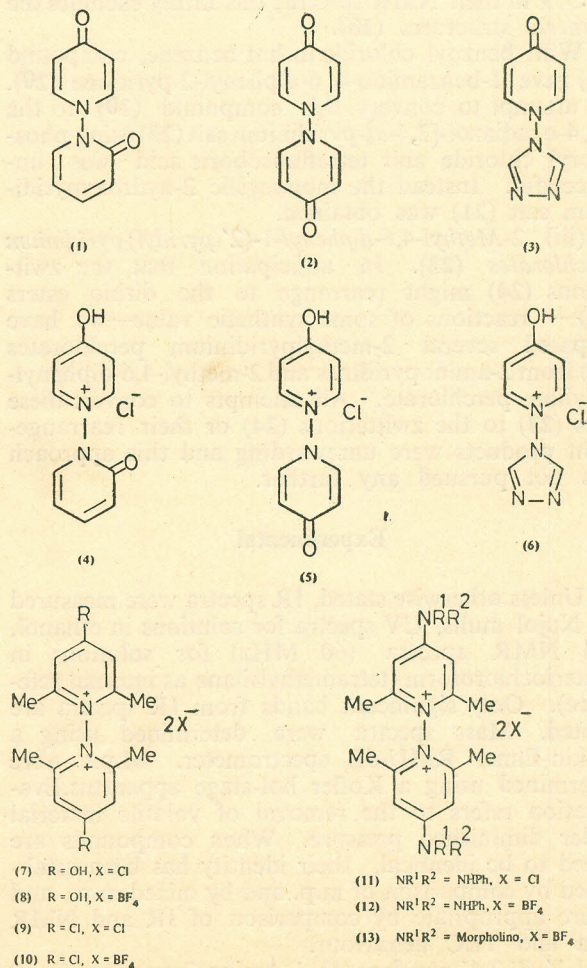
We have recently reported the preparation of a number of novel *N,N'*-linked bisheterocycles [2]. We now describe the preparation of further examples of these systems together with some related chemical transformations.

(i) *Bipyridones*. We have found that 1-amino-2-pyridone and 4-pyrone react in hot pyridine giving 1,1'-bi-2,4'-pyridone (1) and under similar conditions 1-amino-4-pyridone gives 1,1'-bi-4,4'-pyridone (2). The structures of the novel, unsubstituted *N,N'*-linked bispyridones (1 and 2) are fully supported by their spectroscopic properties. The mass spectral fragmentation pattern of compound (2) is shown in Scheme 1: this type of fragmentation is similar to that of the isomeric system (1) and is typical of other *N,N'*-bispyridones which we have reported [2]. The molecular ion ( $M^{+}$ ) is the most intense ion in the spectrum and this fragments by two processes (Scheme 1): (1) cleavage of the N-N bond gives a daughter ion having a composition corresponding to structure *c*; (2) loss of carbon monoxide gives a fragment ion which we have formulated as *a*. The ions *a* and *c* undergo further loss of CO giving the ions *b* or *d*. Compounds (1-3) are converted to their hydrochlorides (4-6) by treatment with acid.

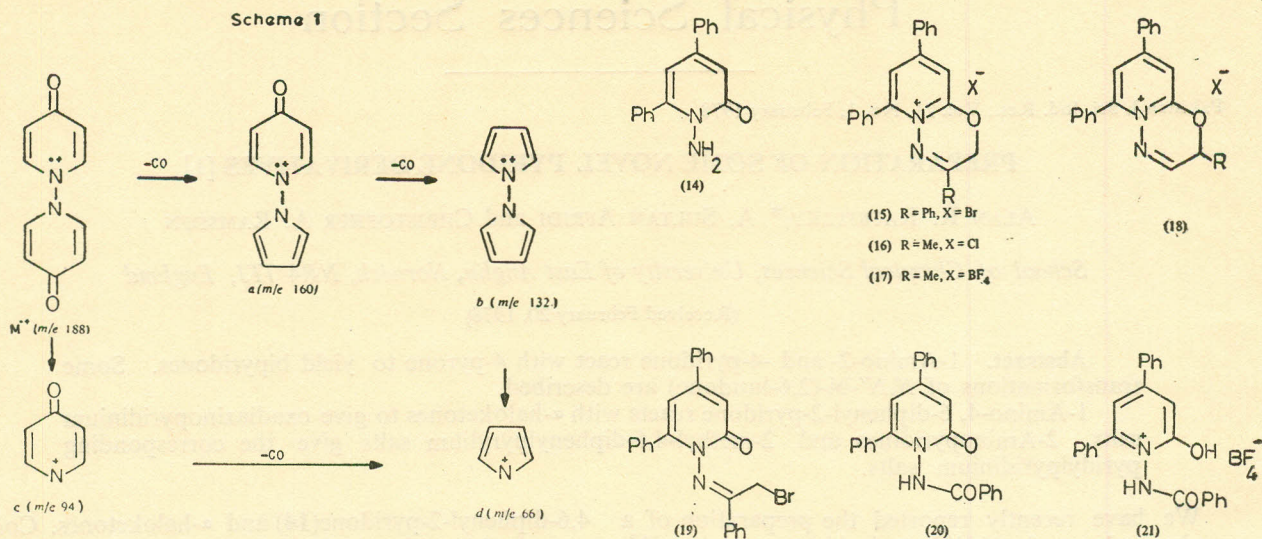
We have previously described the preparation of *N,N'*-bi-2,6-lutidone and its dihydrochloride (7) [2]. This salt (7) has now been converted to several other derivatives. Treatment with tetrafluoroboric acid gives the tetrafluoroborate (8); treatment with phosphoryl chloride gives the 4,4'-dichloro derivative (9). This compound (9), and the tetrafluoroborate salt (10) which is easily prepared from compound (9), are convenient intermediates for preparing diamino derivatives (11-13). The salt (9) with aniline in phosphoryl chloride gave the 4,4'-dianilino compound (11) which was converted into its tetrafluoroborate (12) using a hot solution of tetrafluoroboric acid in ethanol. The tetrafluoroborate (10) with a hot ethanolic solution of morpholine gives the morpholino derivative (13).

(ii) *Condensations of N-Aminopyridones*. An interesting cyclisation reaction occurs between 1-amino-

4,6-diphenyl-2-pyridone(14) and  $\alpha$ -haloketones. Compound (14) with phenacyl bromide in hot ethanol gave a crystalline product which was shown to be the 1,3,4-oxadiazino[1,2-*a*]pyridinium bromide (15). The structure (15) was fully supported by elemental analysis and its spectroscopic properties. The mechanism of formation of the salt (15) pre-







sumably involves the intermediate (19) which is not isolated. In a similar reaction compound (14) and chloroacetone gave the 1,3,4-oxadiazino[1,2-*a*]-pyridinium chloride (16) which was converted to the tetrafluoroborate (17) using tetrafluoroboric acid. All of the novel salts (15-17) show a methylene singlet at  $\tau$ 3.9 in their NMR spectra; this firmly excludes the isomeric structures (18).

With benzoyl chloride in hot benzene, compound (14) gave 1-benzamido-4,6-diphenyl-2-pyridone (20). An attempt to convert this compound (20) to the 1,2,4-oxadiazol-[3,4-*a*]-pyridinium salt (22) using phosphoryl chloride and tetrafluoroboric acid was unsuccessful. Instead the monocyclic 2-hydroxypyridinium salt (21) was obtained.

(iii) 2-Methyl-4,6-diphenyl-1-(2'-pyridyl)pyridinium perchlorates (23). In anticipation that the zwitterions (24) might rearrange to the dithio esters (25)—reactions of some synthetic value—we have prepared several 2-methylpyridinium perchlorates (23) from 2-aminopyridines and 2-methyl-4,6-diphenylpyrylium perchlorate. All attempts to convert these salts (23) to the zwitterions (24) or their rearrangement products were unrewarding and this approach was not pursued any further.

### Experimental

Unless otherwise stated, IR spectra were measured for Nujol mulls, UV spectra for solutions in ethanol, and NMR spectra (60 MHz) for solutions in deuteriochloroform (tetramethylsilane as internal reference). Only significant bands from IR spectra are quoted. Mass spectra were determined using a Perkin-Elmer RMU-6E spectrometer. M.p.s were determined using a Kofler hot-stage apparatus. Evaporation refers to the removal of volatile material under diminished pressure. When compounds are stated to be identical, their identity has been established by comparison of m.p. and by mixed m.p., and where appropriate by comparison of IR and NMR data and TLC behaviour.

1,1'-Bi-2,4'-pyridone (1). 1-Amino-2-pyridone (1.10

g)[3] and 4-pyrone (0.96 g)[4] in pyridine (20 ml) were heated under reflux (12 hr). After cooling the solid which separated was recrystallised from ethanol giving 1,1'-bi-2,4'-pyridone (1) (0.94 g; 50%), prisms, m.p. 233-236°C (Found: C, 63.5; H, 4.3; N, 14.8.  $C_{10}H_8N_2O_2$  requires: C, 63.8; H, 4.3; N, 14.9%);  $\lambda_{max}$  225 ( $\epsilon$ 5000), 265 (13000), 300 nm (5800);  $\nu_{max}$  1640 and 1675  $cm^{-1}$ , (C=O);  $\tau$ 1.3-3.0 (8H, m, aromatic H); *m/e* 188 ( $M^{+\cdot}$ ).

In a similar manner the following compounds were prepared: 1,1'-bi-4,4'-pyridone (2) (0.56 g; 30%), prisms, m.p. 205-210°C (decomp) (Found: C, 63.6; H, 4.5; N, 14.8.  $C_{10}H_8N_2O_2$  requires C, 63.8; H, 4.3; N, 14.9%);  $\lambda_{max}$  220 ( $\epsilon$ 7000), 257 (12000), 275 (13000), and 330 nm (4000);  $\nu_{max}$  1675  $cm^{-1}$  (C=O);  $\tau$ 1.4 (4H, d, CH) and 2.8 (4H, d, CH); *m/e* 188 ( $M^{+\cdot}$ ); and 1-(1',2',4'-triazol-4'-yl)-4-pyridone (3) (0.5 g; 30%), prisms, m.p. 160°C (decomp);  $\lambda_{max}$  210 ( $\epsilon$ 2800) and 265 nm (1100);  $\nu_{max}$  1650  $cm^{-1}$



(C=O);  $\tau$  0.3 (2H, s, CH), 1.1 (2H, d, CH, J 5 Hz) and 2.35 (2H, d, CH, J 5 Hz);  $m/e$  162 ( $M^+$ )—this compound (3) was used without further purification.

1,1'-Bi-2,4'-pyridone hydrochloride (4). Compound (1) (0.2 g) and concentrated hydrochloric acid (3.0 ml) in ethanol (10 ml) were heated at 50°C (1 hr). After cooling, the solid which separated was recrystallised from ethanol giving 1,1'-bi-2,4'-pyridone hydrochloride (4) (0.16 g; 70%), prisms, m.p. 210–212°C (Found: C, 53.1, H, 3.8; N, 12.6.  $C_{10}H_9ClN_2O_2$  requires: C, 53.5; H, 4.0; N, 12.5%);  $\lambda_{max}$  225 ( $\epsilon$  4000), 268 (12000) and 310 nm (5000);  $\nu_{max}$  1680  $cm^{-1}$  (C=O);  $\tau$  1.3–3.2 (8H, m, aromatic H);  $m/e$  188 ( $M^+$ -HCl).

In a similar manner the following compounds were prepared: 1,1'-bi-4,4'-pyridone hydrochloride (5) (0.14 g; 60%), prisms, m.p. 210–230°C (decomp) (Found: C, 53.3; H, 4.1; N, 12.4.  $C_{10}H_9ClN_2O_2$  requires: C, 53.5; H, 4.0; N, 12.5%);  $\lambda_{max}$  220 ( $\epsilon$  6000), 255 (8800), 275 (9200), and 325 nm (3000);  $\nu_{max}$  1640  $cm^{-1}$  (C=O);  $\tau$  1.2–1.4 (4H, m, CH) and 2.4–2.6 (4H, m, CH);  $m/e$  188 ( $M^+$ -HCl) and 1-(1', 2', 4'-triazol-4'-yl)-4-pyridone hydrochloride (6) (0.16 g; 80%), prisms, m.p. 200–202°C (Found: C, 42.6; H, 3.7, Cl, 17.8; N, 28.3.  $C_7H_7ClN_4O$  requires: C, 42.3; H, 3.5; Cl, 17.9; N, 28.2%);  $\lambda_{max}$  265 nm ( $\epsilon$  13800);  $\nu_{max}$  1640  $cm^{-1}$  (C=O);  $\tau$  0.1–3.0 (6H, br. m, CH).

4,4'-Dihydroxy-2,2',6,6'-tetramethyl-1,1'-bipyridinium ditetrafluoroborate (8). 2,2',6,6'-Tetramethyl-1,1'-bi-4,4'-pyridone hydrochloride (7) (0.3 g) [2] and tetrafluoroboric acid (2.0 ml) in ethanol (10 ml) were heated at 50°C (1 hr) and then allowed to cool. The solid which crystallised was identified as 4,4'-dihydroxy-2,2',6,6'-tetramethyl-1,1'-bipyridinium ditetrafluoroborate (8) (0.2 g; 50%) prisms, m.p. 220°C (decomp) (Found: C, 40.2; H, 3.9; N, 6.7.  $C_{14}H_{18}B_2F_8N_2O_2$  requires: C, 40.0; H, 4.3; N, 6.7%);  $\lambda_{max}$  220 ( $\epsilon$  6200) and 275 nm (13000);  $\nu_{max}$  3500–3600 (br. CH) and 1080  $cm^{-1}$  (BF<sub>4</sub>);  $\tau$  2.3 (4H, s, CH) and 7.4 (12H, s, CCH<sub>3</sub>);  $m/e$  246 ( $M^+$  -2BF<sub>4</sub><sup>-</sup>) and 244 ( $M^+$  -2HBF<sub>4</sub>).

4,4'-Dichloro-2,2',6,6'-tetramethyl-1,1'-bipyridinium dichloride (9). Compound (7) (0.3 g) [2] in phosphoryl chloride (10.0 ml) was heated under gentle reflux (2 hr). After cooling ether (20 ml) was added and the solid product identified as compound (9) (0.15 g; 45%), prisms, m.p. 220°C (decomp) (Found: N, 8.1.  $C_{14}H_{16}Cl_4N_2$  requires: N, 7.9%);  $\lambda_{max}$  220 ( $\epsilon$  5400) and 275 nm (10800);  $\nu_{max}$  1620  $cm^{-1}$  (C=N);  $\tau$  2.3 (4H, s, CH) and 7.2 (12H, s, CCH<sub>3</sub>).

4,4'-Dichloro-2,2',6,6'-tetramethyl-1,1'-bipyridinium ditetrafluoroborate (10). Compound (9) (0.35 g) and tetrafluoroboric acid (5 ml) were heated at 80°C (10 min) and the reaction mixture was then scratched with ether (20 ml). The crystalline product was identified as 4,4'-dichloro-2,2',6,6'-tetramethyl-1,1'-bipyridinium ditetrafluoroborate (10) (0.23 g; 50%) prisms, m.p. 260°C (decomp);  $\lambda_{max}$  215 ( $\epsilon$  2800) and 270 nm (9200);  $\nu_{max}$  1050–1120  $cm^{-1}$  (BF<sub>4</sub>);  $\tau$  2.4 (4H, s, CH) and 7.5 (12H, s, CCH<sub>3</sub>). This product was used without further purification.

4,4'-Dianilino-2,2',6,6'-tetramethyl-1,1'-bipyridinium ditetrafluoroborate (12). Compound (9) (0.73 g) and aniline (0.48 g) in phosphoryl chloride (20 ml) were heated

under reflux (2 hr). Ether (40 ml) was added to the cooled reaction mixture giving a solid product which was identified as 4,4'-dianilino-2,2',6,6'-tetramethyl-1,1'-bipyridinium dichloride (11) (0.46 g; 40%), prisms, m.p. 250–252°C (decomp);  $\lambda_{max}$  220 ( $\epsilon$  6000) and 317 nm (9800);  $\nu_{max}$  3320  $cm^{-1}$  (NH);  $\tau$  0.7 (2H, s, NH), 2.4–2.7 (10H, m, aromatic H), 2.8 (2H, s, CH), 2.9 (2H, s, CH), 7.6 (6H, s, CCH<sub>3</sub>) and 7.7 (6H, s, CCH<sub>3</sub>);  $m/e$  396 ( $M^+$ -2Cl). Compound (11) (0.46 g) and tetrafluoroboric acid (2 ml) in ethanol (10 ml) were heated at 60°C (1 hr). The solid which separated on cooling was recrystallised from ethanol giving compound (12) (0.3 g; 50%), prisms, m.p. 265–268°C (Found: C, 51.3; H, 4.9, N, 9.7.  $C_{26}H_{28}B_2F_8N_4 \cdot (H_2O)_2$  requires: C, 51.5; H, 5.3; N, 9.2%);  $\lambda_{max}$  220 ( $\epsilon$  7200) and 318 nm (10800);  $\nu_{max}$  3300 (NH) and 1000–1100  $cm^{-1}$  (BF<sub>4</sub>);  $\tau$  1.0 (2H, s, NH), 2.3–2.6 (10H, m, aromatic H), 2.75 (2H, s, CH), 3.0 (2H, s, CH), 7.6 (6H, s, CCH<sub>3</sub>) and 7.7 (6H, s, CCH<sub>3</sub>);  $m/e$  396 ( $M^+$  -2BF<sub>4</sub><sup>-</sup>).

2,2',6,6'-Tetramethyl-4,4'-dimorpholino-1,1'-bipyridinium ditetrafluoroborate (13). Compound (10) (0.56 g) and morpholine (0.18 g) in ethanol (10 ml) were heated under reflux (2 hr). The solid which separated on cooling was collected and recrystallised from ethanol giving compound (13) (0.17 g; 30%), prisms, m.p. 270–290°C (decomp) (Found: C, 47.6; H, 5.6; N, 9.8.  $C_{22}H_{32}B_2F_8N_4O_2$  requires: C, 47.3; H, 5.7; N, 10.0%);  $\lambda_{max}$  235 ( $\epsilon$  4200) and 315 nm (13200);  $\nu_{max}$  1650 (C=N) and 1000–1100  $cm^{-1}$  (BF<sub>4</sub>);  $\tau$  2.8 (4H, s, CH), 5.8–6.1 (16H, br.d., morpholino H) and 7.7 (12H, s, CCH<sub>3</sub>);  $m/e$  384 ( $M^+$  -2BF<sub>4</sub><sup>-</sup>).

5-Phenyl-1,3,4-oxadiazino[1,2-a]-(4,6-diphenyl)pyridinium bromide (15). Compound (14) (2.6 g) [2] and phenacyl bromide (1.9 g) in pyridine (10 ml) were heated under reflux (8 hr). Evaporation and recrystallisation of the residue from ethanol gave compound (15) (1.7 g; 40%) prisms, m.p. 218–220°C (Found: C, 67.5; H, 4.6; N, 6.4; Br, 18.0.  $C_{25}H_{19}BrN_2O$  requires: C, 67.5; H, 4.3; N, 6.3; Br, 18.2%);  $\lambda_{max}$  220 ( $\epsilon$  11800), 257 (11600), 288 (11800) and 335 nm (11400);  $\nu_{max}$  1630  $cm^{-1}$  (C=N);  $\tau$  2.4–3.0 (17H, m, aromatic H) and 3.9 (2H, s, CH<sub>2</sub>);  $m/e$  363 ( $M^+$  -Br).

In a similar manner, compound (14) (2.6 g) and chloroacetone (0.93 g) in ethanol gave 5-methyl-1,3,4-oxadiazino[1,2-a]-(4,6-diphenyl)pyridinium chloride (16) (1.2 g; 50%), prisms, m.p. 192–194°C (Found: C, 71.1; H, 4.7; Cl, 10.2; N, 8.3.  $C_{20}H_{17}ClN_2O$  requires: C, 71.3; H, 5.1; Cl, 10.6; N, 8.3%);  $\lambda_{max}$  220 ( $\epsilon$  8000) 245 (9000) and 312 nm (13000);  $\nu_{max}$  1660 and 1640  $cm^{-1}$  (C=N);  $\tau$  2.0–2.5 (12H, m, aromatic H), 4.1 (2H, s, CH<sub>2</sub>) and 7.6 (3H, s, CCH<sub>3</sub>)  $m/e$  301 ( $M^+$  -Cl).

5-Methyl-1,3,4-oxadiazino[1,2-a]-(4,6-diphenyl)pyridinium tetrafluoroborate (17). Compound (16) (0.24 g) and tetrafluoroboric acid (2.0 ml) in ethanol were heated under reflux (1 hr). The crystals which separated on cooling were recrystallised from ethanol and identified as compound (17) (0.18 g; 60%) prisms, m.p. 250–252°C (Found: C, 62.0; H, 4.0; N, 6.9.  $C_{20}H_{17}BF_4N_2O$  requires: C, 61.9; H, 4.4; N, 7.2%);  $\lambda_{max}$  220 ( $\epsilon$  8800), 240 (9000) and 315 nm (12200);  $\nu_{max}$  1640–1600 (C=N) and 1100  $cm^{-1}$



(BF<sub>4</sub>);  $\tau$  2.2–2.6 (12H, m, aromatic *H*), 3.9 (2H, s, CH<sub>2</sub>) and 7.8 (3H, s, CCH<sub>3</sub>); *m/e* 301 (*M*<sup>+</sup>–BF<sub>4</sub>).

1-Benzamido-4,6-diphenyl-2-pyridone (20). Compound (14) (2.62 g) [2] and benzoyl chloride (10 ml) in benzene (50 ml) and aqueous hydrochloric acid (50%; 20 ml) were heated at reflux temperature (6 hr). After cooling the solid which separated was recrystallised from ethanol giving compound (20) (2.2 g; 61%), prisms, m.p. 250–300 °C (decomp) (Found: C, 78.5; H, 5.0; N, 7.5. C<sub>24</sub>H<sub>18</sub>N<sub>2</sub>O<sub>2</sub> requires: C, 78.7; H, 4.9; N, 7.7%);  $\lambda_{\max}$  225 ( $\epsilon$  10000), 245 (13000) and 330 nm (3400);  $\nu_{\max}$  1670 and 1640 cm<sup>-1</sup> (C=O);  $\tau$  2.1–3.0 (17H, m, aromatic *H*); *m/e* 366 (*M*<sup>+</sup>).

1-Benzamido-2-hydroxy-4,6-diphenylpyridinium tetrafluoroborate (21). Compound (20) (0.73 g) in phosphoryl chloride (5 ml) was heated at 35°C (1 hr). The reaction mixture was washed with ether (2 × 20 ml) and the residue heated at 50°C with tetrafluoroboric acid (5 ml) for 2 hr. Upon cooling a solid separated which was washed with ether (2 × 10 ml) and recrystallised from ethanol giving compound (21) (0.6 g; 65%), prisms, m.p. 244–246°C (Found: C, 63.7; H, 3.7; N, 5.9. C<sub>24</sub>H<sub>19</sub>BF<sub>4</sub>N<sub>2</sub>O<sub>2</sub> requires: C, 63.4; H, 4.2; N, 6.2%);  $\lambda_{\max}$  220 ( $\epsilon$  6800), 257 (8000) and 315 nm (11400);  $\nu_{\max}$  1620 (C=N) and 1050 cm<sup>-1</sup> (BF<sub>4</sub>);  $\tau$  1.7–2.2 (17H, m, aromatic *H*); *m/e* 367 (*M*<sup>+</sup>–BF<sub>4</sub>) and 366 (*M*<sup>+</sup>–HBF<sub>4</sub>).

2-Methyl-4,6-diphenyl-1-(2'-pyridyl) pyridinium perchlorate (23; R = H). 2-Methyl-4,6-diphenylpyrylium perchlorate (1.0 g) [5] and 2-aminopyridine (0.3 g) in ethanol (20 ml) were heated under reflux (3 hr). The solid product was collected, washed with hot ethanol (2 × 20 ml) and identified as compound (23; R = H) (0.88 g, 70%), prisms, m.p. 220–222°C (Found: C, 65.3; H, 4.6; N, 6.4. C<sub>23</sub>H<sub>19</sub>ClN<sub>2</sub>O<sub>4</sub> requires: C, 65.3; H, 4.5; N, 6.6%);  $\lambda_{\max}$  220 ( $\epsilon$  7800) and 310 nm (11200);  $\nu_{\max}$  1635 (C=N) and 1080 cm<sup>-1</sup> (ClO<sub>4</sub>);  $\tau$  1.0–2.5 (16H, m, aromatic *H*) and 7.2 (3H, s,

CCH<sub>3</sub>); *m/e* 293 (*M*<sup>+</sup>–ClO<sub>4</sub>).

In a similar manner the following pyridinium salts were prepared: 2-methyl-4,6-diphenyl-1,2'-( $\gamma$ -picolyl) pyridinium perchlorate (23; R =  $\gamma$ -Me) (0.88 g; 70%) prisms, m.p. 224–226°C (Found: C, 65.7; H, 4.6; N, 6.7. C<sub>24</sub>H<sub>21</sub>ClN<sub>2</sub>O<sub>4</sub> requires: C, 66.0; H, 4.8; N, 6.4%);  $\lambda_{\max}$  220 ( $\epsilon$  9000) and 315 nm; (13000);  $\nu_{\max}$  1635 (C=N) and 1080 cm<sup>-1</sup> (ClO<sub>4</sub>);  $\tau$  1.1–2.5 (15H, m, aromatic *H*), 7.25 (3H, s, CCH<sub>3</sub>) and 7.3 (3H, s, CCH<sub>3</sub>); 2-methyl-4,6-diphenyl-1,6'-( $\beta$ -picolyl) pyridinium perchlorate (23, R =  $\beta$ -Me) (0.66 g; 53%), prisms, m.p. 218–220°C. (Found: C, 65.7; H, 4.9; N, 6.4. C<sub>24</sub>H<sub>21</sub>ClN<sub>2</sub>O<sub>4</sub> requires: C, 66.0; H, 4.8; N, 6.4%);  $\lambda_{\max}$  220 ( $\epsilon$  8500) and 312 nm (12000);  $\nu_{\max}$  1630 (C=N) and 1080 cm<sup>-1</sup> (ClO<sub>4</sub>);  $\tau$  1.2–2.5 (15H, m, aromatic *H*), 7.25 (3H, s, CCH<sub>3</sub>) and 7.35 (3H, s, CCH<sub>3</sub>).

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