

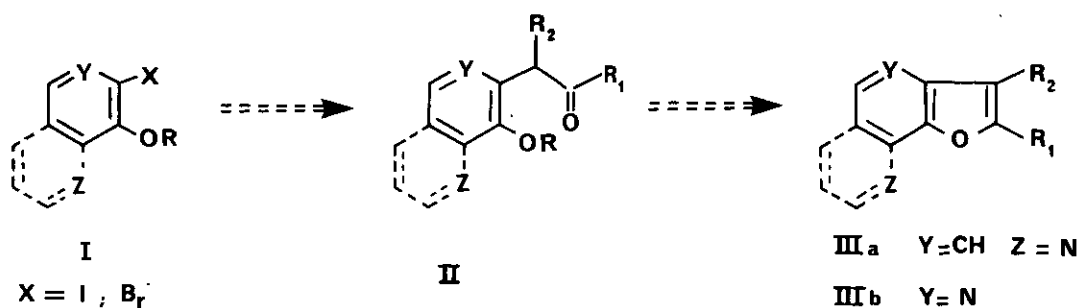
A CONVENIENT ACCESS TO FURO[3,2-h]QUINOLINES
AND TO FURO[3,2-b]PYRIDINES VIA $S_{RN}1$ REACTIONS¹

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Abstract - The two steps route to furo[3,2-h]quinolines **4** or to furo[3,2-b]pyridines **17** involves an $S_{RN}1$ reaction between 5-chloro-7-iodo-8-isopropoxyquinoline **1a** or 2-bromo-3-isopropoxy-pyridine **15** and enolates derived from ketones. The substitution products **3** or **16**, lead to the title compounds under acidic treatment.

In contrast with natural furo[2,3-b]quinolines or with other furoquinolines in which the pyridine ring is fused to the furan², isomeric furoquinolines containing the benzofuran moiety have been less documented.³⁻⁷ This fact, together with a recent report on a four steps-synthesis of furo[3,2-b]pyridine,⁸ a member of a large class of heterocycles^{9,10} prompted us to publish our new and straightforward access to the title heterocycles.

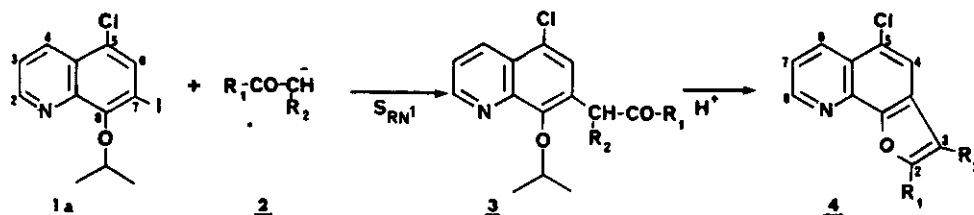


Scheme 1

Our approach to the furoquinoline system **IIIa** ($Y = \text{CH}; Z = \text{N}$) and furopyridine **IIIb** ($Y = \text{N}$) (Scheme 1) involves the heterocyclisation of β (ortho-alkoxyhetaryl)ketones **II** obtained by reacting properly substituted substrates **I**, with various enolates $\text{R}_2\text{CH}=\text{C}(\text{O}^-)\text{R}_1$ under $S_{RN}1$ conditions.¹¹

Synthesis of Furo[3,2-h]quinolines

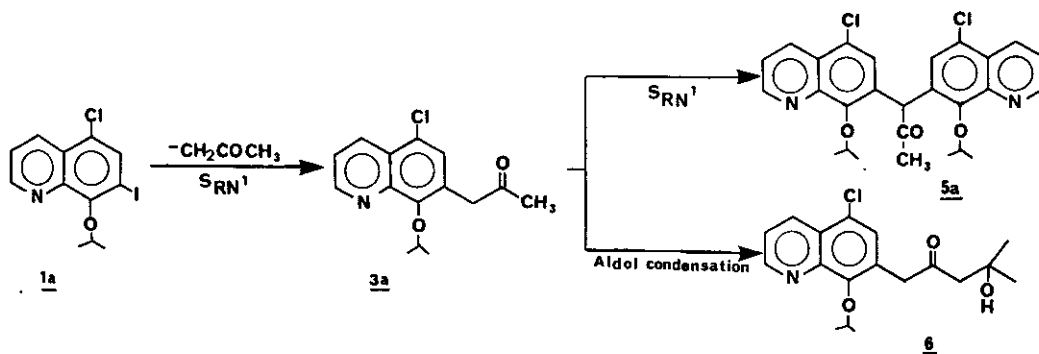
As a convenient model for I, we selected the 5-chloro-7-iodo-8-hydroxyquinoline **1** (Clioquinol) recently shown in our laboratory to easily undergo substitution by sulfanions on position 7 via an $S_{RN}1$ reaction.¹ The free phenolic function, being not compatible with the $S_{RN}1$ mechanism¹² had to be protected and all reactions were thus performed on 8-isopropoxy or on 8-methoxy derivatives which are stable under the basic conditions of the $S_{RN}1$ reaction.



Scheme 2

Enolates derived from various ketones **2a-e**, treated in liquid ammonia with **1a** under illumination afforded **3a-e** in 36-80% yield (Table 1). That the mechanism of the aromatic nucleophilic substitution was indeed $S_{RN}1$ was shown by classical criteria: A model reaction between **1a** and **2a** was significantly inhibited i) in the dark, because of the lack of activation energy to initiate the chain process. ii) when 1,4-dinitrobenzene (10%) was added to the photostimulated reaction medium, since this electron acceptor does not allow the chain propagation.

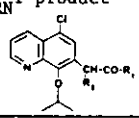
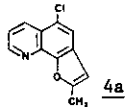
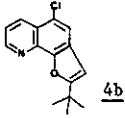
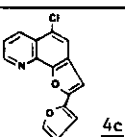
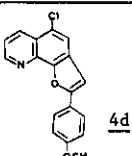
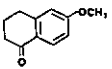
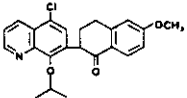
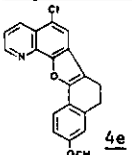
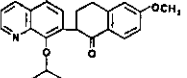
The primary $S_{RN}1$ reaction products **3a-d** being themselves enolisable ketones may behave as nucleophiles toward **1a** in a subsequent $S_{RN}1$ reaction to give low yields of **5a-d***; moreover **3a** may undergo an aldol reaction under the basic conditions and gave **6** (10%). Both reactions (Scheme 3) have precedents in the literature on $S_{RN}1$ reactions.^{13, 14}



Scheme 3 Secondary products from **1a**

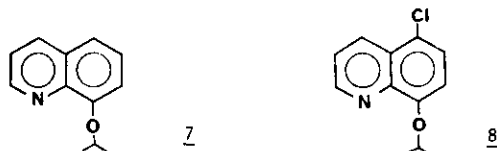
*The first of these side products **5a** (9%) was purified for structural determination while the others were isolated and characterized by their mass spectrum: **5b** (9%), 540-538 (M^+); **5c** (5%), 550-548 (M^+); **5d** (9%) 590-588 (M^+).

Table 1

Substrate  <u>1a</u>	Ketone enolate <u>2</u>	S _{RN1} conditions solvent time ^a	S _{RN1} product ^b  <u>3</u>	Corresponding furoquinoline <u>4</u>
<u>1a</u>	<u>2a</u> CH ₃ -CO-CH ₃	NH ₃ hv; 1h	R ₁ = CH ₃ R ₂ = H <u>3a</u> = 73%	 <u>4a</u>
<u>1a</u>	<u>2b</u> CH ₃ -CO-C ^t C ₄ H ₉	NH ₃ hv; 1h	R ₁ = C ^t C ₄ H ₉ R ₂ = H <u>3b</u> = 70%	 <u>4b</u>
<u>1a</u>	<u>2c</u> CH ₃ -CO-C ₄ H ₃ O	NH ₃ hv; 1h	R ₁ = C ₄ H ₃ O R ₂ = H <u>3c</u> = 80%	 <u>4c</u>
<u>1a</u>	<u>2d</u> CH ₃ -CO-C ₆ H ₄ p.OCH ₃	NH ₃ hv; 1h	R ₁ = C ₆ H ₄ p.OCH ₃ R ₂ = H <u>3d</u> = 70%	 <u>4d</u>
<u>1a</u>	<u>2e</u> 	Me ₂ SO dark; 0.5h	 <u>3e</u> = 36%	 <u>4e</u>
<u>1a</u>	<u>2e</u>	NH ₃ hv; 1h	 <u>14e</u> = 35%	
 <u>13</u>	<u>2e</u>	NH ₃ hv; 3h	<u>14e</u> = 44%	
<u>13</u>	<u>2f</u> CH ₃ CH ₂ COCH ₂ CH ₃	NH ₃ hv; 1h	R ₁ = CH ₂ CH ₃ R ₂ = CH ₃ <u>14f</u> = 70%	

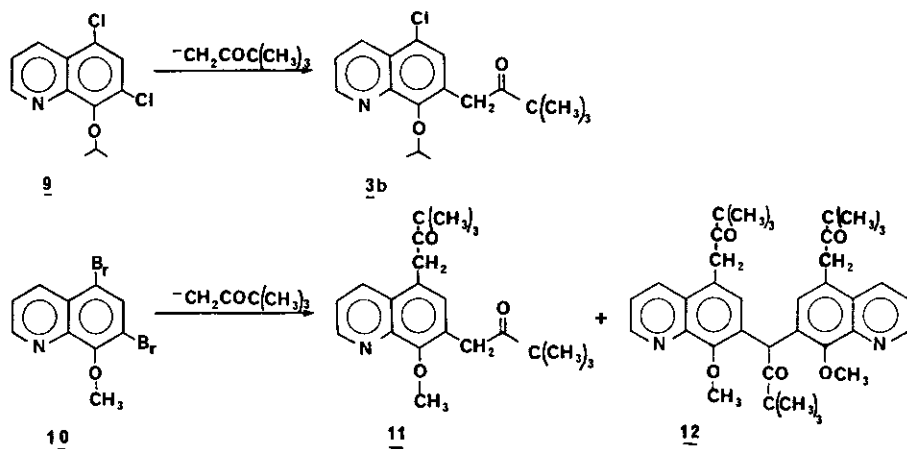
^a hv: irradiation with Hanovia 450 W medium pressure mercury lamp.^b Yields for pure products after isolation.

The photostimulated reaction of 1a with the 6-methoxy-1-tetralone derived enolate 2e, which is known to be an efficient nucleophile in some $S_{RN}1$ reactions,¹⁵ afforded as major product 8-isopropoxyquinoline 7 resulting from the reductive elimination of both (7)-I and (5)-Cl and a modest yield (35%) of 2-[7-(8-isopropoxy)quinolyl]-6-methoxy-1-tetralone 14e. The 7-chloro-quinolyl analog 3e was nevertheless obtained (36%) when the reaction was performed in Me₂SO as solvent in the dark;¹⁶ under photostimulation, only 5-chloro-8-isopropoxyquinoline 8 was obtained.



The competition between substitution and reduction was often observed in $S_{RN}1$ reactions involving enolates such as 2e where β hydrogen atoms are available,^{17,18} but we are not aware of precedent concerning a solvent effect on the reduction pathway taking place on dihalo aromatic compounds.¹⁹

Although the double $S_{RN}1$ reaction was known to occur on dihalobenzene treated with various ketone enolates,^{13,20} we observed it neither on the 5-chloro-7-iodo-8-isopropoxyquinoline 1a nor on the 5,7-dichloro-8-isopropoxyquinoline 9. These substrates carrying either Cl or I on position 7, when treated with 2b underwent monosubstitution only and gave identical yields 70% of 3b. In contrast, a model experiment carried out on 5,7-dibromo-8-methoxyquinoline 10 led to the doubly substituted product 11 (60%) together with 12 (15%) whose formation is similar to that of 5 (see above). Finally we have observed that the presence of an halogen on position 5 was not necessary for the $S_{RN}1$ reaction to occur as exemplified by the substitution products 14e,f issued from reactions between 7-iodo-8-isopropoxyquinoline 13 and enolates derived from 2e,f (Table 1).



Scheme 4

The treatment of the β (ortho-isopropoxyhetaryl) ketones 3a-e with HBr 45%/AcOH at 100°C quantitatively led to the furo[3,2-h]quinolines 4a-e. The treatment of the aforementioned ketones by iodotrimethylsilane, which in our hands had promoted quantitatively both the OH deprotection and the heterocyclisation to benzofurans¹¹ was not here as much efficient, leading only to partial cyclisation.

Synthesis of Furo[3,2-b]pyridines

Hydroxypyridines ortho substituted by a proper leaving group are the starting materials on which the $S_{RN}1$ substitution reaction had to be performed for synthesizing furopyridines by the above method (scheme 1). To illustrate the feasibility of this reaction, we selected compound 15 which can be easily prepared from the commercially available 2-bromo-3-hydroxypyridine. The treatment of 15 by enolates derived from 2b,g under standard $S_{RN}1$ conditions (photostimulation, in liquid ammonia) gave high yields of the corresponding 8-(ortho-isopropoxy)pyridyl)ketones 16b,g. The substitution product 16d was obtained in near quantitative yield (98%) just by changing liquid ammonia at -33°C for Me_2SO at room temperature. The acetophenone derived enolate 2f, previously reported not to react with 2-bromopyridine²¹ happened to be an efficient nucleophile toward 15 in Me_2SO to give 16f (Table 2).

The acidic treatment of 16b,d,f,g led quantitatively to the corresponding furo[3,2-b]pyridines 17b,d,f,g.

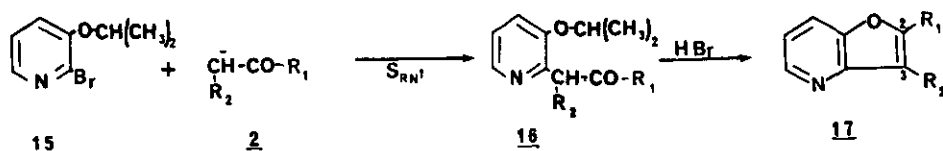


Table 2.

Substrate	Ketone enolates	$S_{RN}1$ conditions: solvent time ^a	$S_{RN}1$ product	Corresponding furopyridine
<u>15</u>			<u>16</u>	<u>17</u>
<u>15</u>	$\text{CH}_3\text{-CO-C(CH}_3)_3$ <u>2b</u>	NH_3 hv; 0.25h	$\text{R}_1 = \text{C(CH}_3)_3$ $\text{R}_2 = \text{H}$ <u>16b</u> 70%	 <u>17b</u>
<u>15</u>	$\text{CH}_3\text{-COC}_6\text{H}_4\text{p.OCH}_3$ <u>2d</u>	NH_3 hv; 7h	$\text{R}_1 = \text{C}_6\text{H}_5\text{OCH}_3$ $\text{R}_2 = \text{H}$ <u>16d</u> 30% ^d	 <u>17d</u> ^c
<u>15</u>	<u>2d</u>	Me_2SO hv; 3h	<u>16d</u> 98%	<u>17d</u>
<u>15</u>	$\text{CH}_3\text{-CO-C}_6\text{H}_5$ <u>2f</u>	Me_2SO hv; 6h	$\text{R}_1 = \text{C}_6\text{H}_5$ $\text{R}_2 = \text{H}$ <u>16f</u> 70%	 <u>17f</u>
<u>15</u>	$\text{C}_2\text{H}_5\text{-CO-C}_2\text{H}_5$ <u>2g</u>	NH_3 hv; 1h	$\text{R}_1 = \text{C}_2\text{H}_5$ $\text{R}_2 = \text{CH}_3$ <u>16g</u> 86%	 <u>17g</u>

a) hv: irradiation with Hanovia 450W medium pressure mercury lamp. b) Yields for pure 8-(o-isopropoxy)pyridyl)ketones after isolation. c) OCH_3 partially hydrolyzed in the reaction with HBr 45% at 100°C . d) Unchanged substrate recovered ~60%.

This study showing that furopyridines and furoquinolines are obtained from halopyridine and haloquinolines carrying an hydroxy function ortho to the leaving group enlarges thus the scope of the $S_{RN}1$ based methodology for heterocyclic synthesis.²²

EXPERIMENTAL

Melting points are uncorrected and were measured on a Reichert melting point apparatus. Low-resolution mass spectra were obtained on an AEI MS 50 spectrometer; 1H nmr spectra (in $CDCl_3$) were recorded with Perkin-Elmer R 12 or Varian EM 360 instrument; chemical shifts from tetramethylsilane are given in δ . Purifications were achieved by column chromatography (C.C) or by preparative thin-layer chromatography (P.T.L.C.).

Starting Materials

5-Chloro-7-iodo-8-hydroxyquinoline **1**, 5,7-Dichloro-8-hydroxyquinoline, 5,7-Dibromo-8-hydroxyquinoline and 2-Bromo-3-hydroxypyridine are commercially available; 7-Iodo-8-hydroxyquinoline was prepared by iodation of 8-Hydroxyquinoline.²³ The corresponding ethers were obtained by treating those materials (10 mmol) dissolved in DMF (20 ml) with CO_3K_2 (2.5 g) and 2-bromopropane (2 ml) or iodomethane (1.25 ml) and heating at 80°C for 2 h. Classical work up and purification (C.C.) on silica gel, elution with CH_2Cl_2 , afforded **1a**, **9**, **10**, **13**, **15**.

5,7-Dichloro-8-isopropoxyquinoline **9**

Mp 43-45°C, nmr δ 1.40 (d, 6H, J = 6,6 Hz), 5.15 (sept, 1H, J = 6,6 Hz), 7.50 (dd, 1H = H_3 , $J_{3,4}$ = 9 Hz, $J_{2,3}$ = 4,6 Hz), 7.65 (s, 1H = H_6), 8.55 (dd, 1H = H_4 , $J_{3,4}$ = 9 Hz, $J_{2,4}$ = 1,9 Hz), 9.00 (dd, 1H = H_2 , $J_{2,3}$ = 4,6 Hz, $J_{3,4}$ = 9 Hz, $J_{2,4}$ = 1,9 Hz), * ms m/z 259-257-255 (M^+) 217-215-213. Anal.Calcd for $C_{12}H_{11}Cl_2NO$: C, 56.30; H, 4.29. Found: C, 56.36; H, 4.15.

5,7-Dibromo-8 methoxyquinoline **10**

Mp 104-105°C, nmr δ 4.15 (s, 3H), 7.50 (dd, 1H), 7.95 (s, 1H), 8.45 (dd, 1H), 8.95 (dd, 1H), ms m/z 319-317-315 (M^+), 288-286-284, 207-205. Anal.Calcd for $C_{10}H_7Br_2NO$: C, 37.90; H, 2.20. Found: C, 38.15; H, 2.18.

7-Iodo-8-isopropoxyquinoline **13**

Mp 105-106°C, nmr δ 1.60 (d, 6H), 4.80 (sept, 1H), 6.90 (d, 1H), 7.50 (dd, 1H), 8.0 (d, 1H), 8.30 (dd, 1H), 8.90 (dd, 1H), ms m/z 313 (M^+) 298, 271, 255. Anal.Calcd for $C_{12}H_{12}INO$: C, 46.04; H, 3.83. Found: C, 46.22; H, 3.75.

2-Bromo-3-isopropoxyppyridine **15**

Liquid. Nmr δ 1.40 (d, 6H, J = 6,6 Hz), 4.60 (sept, 1H, J = 6,6 Hz), 7.25 (m, 2H = H_4 + H_5), 8.0 (dd, 1H = H_6), ms m/z = 217-215 (M^+), 175-173.

$S_{RN}1$ General Procedure

To liquid ammonia (50 ml) under argon in a 100 ml three-necked Pyrex flask fitted with a dry ice condenser were added the ketone (4 mmol), freshly sublimed $t-C_4H_9OK$ (4 mmol), and the substrate (1 mmol). The flask was illuminated with 450 W pressure mercury lamps (Hanovia). The course of the reaction was monitored by analyzing aliquots (TLC) and after consumption of the substrate the reaction was quenched by adding NH_4Cl . After evaporation of the solvent, water

*J Values measured for derived products are not significantly different and are not worth further mentioning.

(50 ml) was added, and the crude product was extracted with methylene chloride (3 x 20 ml). Workup and purification (P.T.L.C.) gave pure products. Reactions in Me₂SO (distilled in glass-Flika) were made under argon bubbling at room temperature (20-30°C). Products were extracted by CH₂Cl₂ (3 x 20 ml) after saturation with water. Cyclization to Furoquinoline and Furopyridine

The furoquinolines were obtained by heating samples of 3(a-e) in acetic acid (5 mL) with HBr 45% (0.5 mL) at 100°C for 4 to 6 h in a stoppered tube, whereas 1(b,d,f,g) had to be treated more vigorously by heating overnight in pure HBr 45%. Work up and purification (P.T.L.C.) led to the cyclised products 4 or 17.

7-Acetyl-5-chloro-8-isopropoxyfuroquinoline 3a
 Mp 98-99°C, nmr δ 1.35 (d, 6H), 2.25 (s, 3H), 4.0 (s, 2H), 5.35 (sept, 1H), 7.50 (s, dd, 2H), 8.55 (dd, 1H), 9.0 (dd, 1H), ms m/z 279-277 (M⁺), 237-235, 194-192.
5-Chloro-2-methyl-3,2-h]quinoiline 4a
 Mp 100-101°C, nmr δ 2.60 (s, 3H), 6.45 (s, 1H), 7.50 (dd, 1H), 7.75 (s, 1H), 8.65 (dd, 1H), 9.0 (dd, 1H), ms m/z = 219-217 (M⁺). Anal. Calcd for C₁₂H₈ClNO: C, 66.22; H, 3.71; N, 6.44; O, 7.35. Found: C, 66.10; H, 3.76; N, 6.32; O, 7.38.
5-Chloro-8-isopropoxy-7-pivaloylmethylquinoiline 3b
 Mp 69-71°C, nmr δ 1.30 (m, 15H), 4.0 (s, 2H), 5.3 (sept, 1H), 7.35 (s, dd, 2H), 8.40 (dd, 1H), 8.80 (dd, 1H), ms m/z 321-319 (M⁺), 279-277, 264-262, 194-192.
5-Chloro-2-tert-butyl-3,2-h]quinoiline 4b
 Viscous. nmr δ 1.50 (s, 9H), 6.45 (s, 1H), 7.45 (dd, 1H), 7.70 (s, 1H), 8.65 (dd, 1H), 9.0 (dd, 1H), ms m/z 261-259 (M⁺). Anal. Calcd for C₁₅H₁₄ClNO: C, 69.39; H, 5.40; N, 5.39; O, 6.16. Found: C, 69.33; H, 5.46; N, 5.29; O, 6.10.
5-Chloro-7-(2-furanyl)-8-isopropoxyquinoiline 3c
 Mp 96-98°C, nmr δ 1.35 (d, 6H), 4.40 (s, 2H), 5.30 (sept, 1H), 6.30 (dd, 1H), 7.40 (m, 2H), 7.60 (m, 2H), 8.50 (dd, 1H), 8.90 (dd, 1H), ms m/z 331-329 (M⁺), 289-287, 194-192. Anal. Calcd for C₁₈H₁₆ClNO₂: C, 65.58; H, 4.85; N, 4.25; O, 14.56. Found: C, 65.41; H, 4.84; N, 4.40; O, 14.30.
5-Chloro-2-(2-furanyl)-furo[3,2-h]quinoiline 4c
 Mp 155-157°C, nmr δ 6.65 (dd, 1H), 7.20 (m, 2H), 7.60 (m, 2H), 8.0 (s, 1H), 8.80 (dd, 1H), 9.10 (dd, 1H), ms m/z 271-269 (M⁺). Anal. Calcd for C₁₅H₈ClNO₂: C, 66.82; H, 2.96; N, 5.19; O, 11.87. Found: C, 66.90; H, 2.82; N, 4.92; O, 11.63.
5-Chloro-8-isopropoxy-7-p-methoxyphenacylquinoiline 3d
 Mp 107-108°C, nmr δ 1.35 (d, 6H), 3.80 (s, 3H), 4.45 (s, 2H), 5.25 (sept, 1H), 6.90 (d, 2H), 7.40 (dd, 1H), 7.55 (s, 1H), 8.10 (d, 2H), 8.50 (dd, 1H), 8.90 (dd, 1H), ms m/z 371-369 (M⁺), 312-310.
5-Chloro-2-p-methoxyphenacylfuro[3,2-h]quinoiline 4d
 Mp 213-215°C, nmr δ 3.85 (s, 3H), 6.90 (d, 2H), 7.0 (s, 1H), 7.45 (dd, 1H), 7.80 (d, 2H), 8.0 (s, 1H), 8.60 (dd, 1H), 9.0 (dd, 1H), ms m/z 311-309 (M⁺). Anal. Calcd for C₁₈H₁₂ClNO₂: C, 69.74; H, 3.87; N, 4.50; O, 10.33. Found: C, 69.49; H, 3.80; N, 4.50; O, 10.70.
2-[7-(5-Chloro-8-isopropoxy)-quinoil-1-yl]-6-methoxy-1-tetraolone 3e
 Mp 158-160°C, nmr δ 1.20-1.40 (d, 6H), 2.50 (m, 2H), 3.0 (m, 2H), 3.8 (s, 3H), 4.5 (dd, 1H), 5.10 (sept, 1H), 6.7 (s, 1H), 6.8 (dd, 1H), 7.25 (s, 1H), 7.35 (dd, 1H), 8.0 (d, 1H), 8.45 (dd, 1H), 8.9 (dd, 1H), ms m/z 397-395 (M⁺), 354-352, 338-336.

2,3-[1,2-(3,4-Dihydro-6-methoxy)-naphthyl]-5-chlorofuro[3,2-h]quinoline 4e

Mp 190-194°C, nmr δ 3.0 (m, 4H), 3.80 (s, 3H), 6.80 (s, d, 2H), 7.50 (dd, 1H), 7.70 (s, 1H), 7.85 (d, 1H), 8.6 (dd, 1H), 9.05 (dd, 1H), ms m/z 337-335 (M^+), 322-320. Anal. Calcd for $C_{20}H_{14}ClNO_2$: C, 71.56; H, 4.17; N, 4.17. Found: C, 71.29; H, 3.94; N, 4.12.

1,1-Di[7-(5-chloro-8-isopropoxy)-quinolyl]-2-propanone 5a

Mp 166-167°C, nmr δ 1.30-1.40 (d, d, 12 H), 2.40 (s, 3H), 5.70 (sept, 2H), 6.50 (s, 1H), 7.45 (s, 2H), 7.50 (dd, 2H), 8.55 (dd, 2H), 9.0 (dd, 2H), ms m/z 500-498-496 (M^+), 455-453, 439-437, 413-411.

1-[7-(5-Chloro-8-isopropoxy)-quinolyl]-4-hydroxy-4-methyl-2-pentanone 6

Mp 83°C, nmr δ 1.25-1.40 (s, m, 12H), 2.65 (s, 2H), 3.90 (s, 2H), 5.35 (sept, 1H), 7.40 (s, 1H), 7.50 (dd, 1H), 8.55 (dd, 1H), 9.0 (dd, 1H), ms m/z 337-335 (M^+), 322-320, 295-293.

8-Isopropoxyquinoline 7

Viscous. Nmr δ 1.55 (d, 6H), 4.85 (sept, 1H), 7.01 (dd, 1H), 7.40 (m, 3H), 8.15 (dd, 1H), 9.0 (dd, 1H), ms m/z 187 (M^+), 172, 145.

5-Chloro-8-isopropoxyquinoline 8 (lit. 1)

5,7-Dipivaloylmethyl-8-methoxyquinoline 11

Mp 133°C, nmr δ 1.25 (m, 18H), 4.0 (broad s, 5H), 4.10 (s, 2H), 7.0 (s, 1H), 7.30 (dd, 1H), 7.95 (dd, 1H), 8.80 (dd, 1H), ms m/z 355 (M^+), 340, 298, 270, 256. Anal. Calcd for $C_{22}H_{29}NO_3$: C, 74.38; H, 8.16; N, 3.94; O, 13.51. Found: C, 74.15; H, 8.30; N, 4.02; O, 13.70.

1,1-Di[7-(5-pivaloylmethyl-8-methoxy)-quinolyl]-3,3-dimethyl-2-butanone 12

Viscous. Nmr δ 1.30 (s, s, s, 27H), 4.2-4.4 (s, s, s, 10H), 7.05 (s, 1H), 7.3-7.6 (m, 4H), 8.2 (dd, 1H), 8.6 (dd, 1H), 9.0 (dd, 2H), ms m/z 610 (M^+), 525, 427.

2-[7-(8-Isopropoxy)-quinolyl]-6-methoxy-1-tetralone 14e

Mp 120°C, nmr δ 1.45 (d, 6H), 2.45 (m, 2H), 3.0 (m, 2H), 3.8 (s, 3H), 4.30 (m, 1H), 4.75 (sept, 1H), 6.7-7.4 (m, 5H), 8.0 (m, 2H), 8.9 (dd, 1H), ms m/z 361 (M^+), 346, 319. Anal. Calcd for $C_{23}H_{23}NO_3$: C, 76.47; H, 6.37; N, 3.87; O, 13.29. Found: C, 76.15; H, 6.68; N, 3.67; O, 13.59.

2-[7-(8-Isopropoxy)-quinolyl]-3-pentanone 14f

Viscous. Nmr δ 1.0 (t, 3H), 1.45 (broad d, 9H), 2.30 (q, 2H), 4.25 (q, 1H), 4.80 (sept, 1H), 7.0 (d, 1H), 7.25 (d, 1H), 7.40 (dd, 1H), 8.30 (dd, 1H), 8.90 (dd, 1H), ms m/z 271 (M^+), 256, 214.

3-Isopropoxy-2-pivaloylmethylpyridine 16b

Viscous. Nmr δ 1.3 (m, 15H), 4.05 (s, 2H), 4.55 (sept, 1H), 7.10 (m, 2H), 8.15 (dd, 1H), ms m/z 235 (M^+), 220, 178, 150.

2-Isobutylfuro[3,2-b]pyridine 17b

Liquid. Nmr δ 1.40 (s, 9H), 6.55 (s, 1H), 7.10 (dd, 1H, $J = 5$ Hz and $J = 8$ Hz), 7.60 (dd, 1H, $J = 8$ Hz), 8.40 (dd, 1H, $J = 5$ Hz), ms m/z 175 (M^+), 160. Anal. Calcd for $C_{11}H_{13}NO$: C, 75.45; H, 7.42; N, 7.99; O, 9.14. Found: C, 75.0; H, 7.46; N, 8.18; O, 9.40.

3-Isopropoxy-2-p-methoxyphenacylpyridine 16d

Viscous. Nmr δ (enol form) 1.25 (d, 6H), 3.80 (s, 3H), 4.40 (sept, s, 2H), 6.8-7.1 (m, 4H), 8.0 (d, 2H), 8.1 (t, 1H), ms m/z 285 (M^+), 226, 135, 107.

2-p-Methoxyphenylfuro[3,2-b]pyridine 17d

Mp 100-103°C, nmr δ 3.90 (s, 3H), 7.15 (m, 4H), 7.85 (m, 3H), 8.55 (dd, 1H), ms m/z 225 (M^+), 210. Anal. Calcd for $C_{14}H_{11}NO_2$: C, 74.68; H, 4.88; N, 6.22; O, 14.21. Found: C, 74.36; H, 5.18; N, 6.09; O, 14.15.

3-Isopropoxy-2-phenacylpyridine 16f

Viscous. Nmr δ (enol form) 1.20 (m, 6H), 4.40 (s, sept, 2H), 6.9 (m, 2H), 7.25 (m, 3H), 7.80 (m, 3H), ms m/z 255 (M^+), 212, 196, 105, 77.

2-Phenylfuro[3,2-b]pyridine 17f

Mp 87-90°C, nmr δ 7.35 (m, 2H), 7.60 (m, 3H), 8.0 (m, 3H), 8.70 (dd, 1H), ms m/z 195 (M^+), 167. Anal. Calcd for $C_{13}H_9NO$: C, 80.01; H, 4.61; N, 7.17; O, 8.19. Found: C, 79.95; H, 4.91; N, 6.93; O, 8.21.

2-[2-(3-Isopropoxy-2-pyridyl)]-3-pentanone 16g

Liquid. Nmr δ 1.0 (t, 3H), 1.30 (d, 6H), 1.40 (d, 3H), 2.40 (q, 2H), 4.20 (q, 1H), 4.55 (sept, 1H), 7.05 (m, 2H), 8.0 (t, 1H), ms m/z 221 (M^+), 165, 123, 106.

2-Ethyl-3-methylfuro[3,2-b]pyridine 17g

Liquid. Nmr δ 1.35 (t, 3H), 2.40 (s, 3H), 2.90 (q, 2H), 7.40 (dd, 1H), 7.90 (dd, 1H), 8.65 (dd, 1H), ms m/z 161 (M^+), 146. Anal. Calcd for $C_{10}H_{11}NO$: C, 74.55; H, 6.83; N, 8.69; O, 9.93. Found: C, 74.34; H, 7.15; N, 8.63; O, 9.88.

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