Tetrahedron Vol 49, No 43, pp 9767-9774, 1993
Printed in Great Britain

0040-4020/93 $6 00+ 00

Synthesis and NMR Structural Study of Furoquinolines and Naphthofurans from Quinones and a 1-Azadiene

Pascal Nebois, Houda Fillion,* and Leila Benameur

Laboratoire de Chimie Organique, Institut des Sciences Pharmaceutiques et Biologiques, Université Claude Bernard, 8, avenue Rockefeller, F-69373 Lyon Cedex 08, France

Bernard Fenet

Centre de RMN, Université Claude Bernard, F-69622 Villeurbanne Cedex, France

Jean-Louis Luche

Laboratoire AMPERES, Université Paul Sabatier, 118 route de Narbonne, 31062 Toulouse Cedex, France

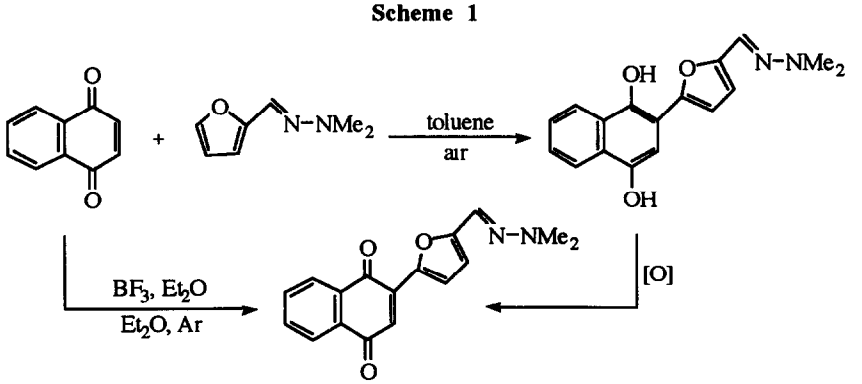
(*Received in Belgium* 14 *May* 1993, *accepted* 20 *July* 1993)

Key Words 1-azadiene, quinone, furoquinoline, naphthofuran, 2D ^{1}H-^{13}C HMBC , 1D ^{1}H NOE DIFF

Abstract The ability of 2-ethoxybut-2-enal N,N-dimethylhydrazone to give with quinoline-5,8-diones or 1,4-naphthoquinones, either a [4+2] cycloaddition in a neutral medium or a [3+2] process in the presence of trifluoroacetic acid is described A 2D ^{1}H-^{13}C HMBC and 1D ^{1}H NOE DIFF study is made in order to confirm the structures

The use of α,β-unsaturated N,N-dimethylhydrazones to build nitrogen six-membered rings through a hetero Diels-Alder reaction has been successfully exploited [1] However, although the ability of such reagents to afford nucleophilic additions to electrophiles was reported,[2] only very few examples on their Michael addition were till now described Thus, the preferred reaction of furan-2-carboxaldehyde N,N-dimethylhydrazone was a nucleophilic addition of the furan nucleus to the conjugated double bond of 1,4-naphthoquinone[3] (Scheme 1)

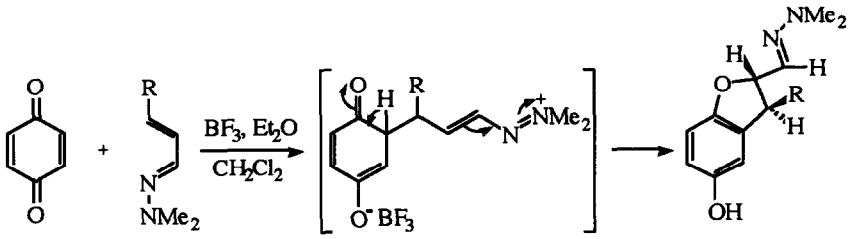
Scheme 1



Similar reactions were also obtained by Potts *et al* [3] with benzoquinone, 5-acetoxy-1,4-naphthoquinone, quinoline-5,8-dione and isoquinoline-5,8-dione

With acyclic azadienes such as cinnamaldehydes or crotonaldehyde N,N-dimethylhydrazones and in the presence of boron trifluoride etherate, a Michael addition of C-3 of these 1-azadienes to benzoquinone was observed yielding by ring closure of the intermediate, dihydrobenzofuran derivatives (Scheme 2)[1l]

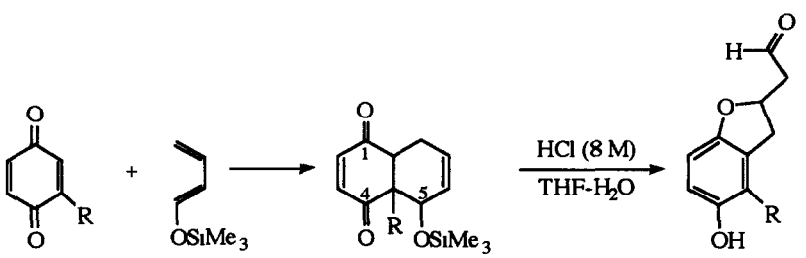
Scheme 2



R=Me, Ph, o-MeO-C_6H_4

Formation of analogous dihydrobenzofurans was however reported to occur under acidic conditions from the Diels-Alder adducts of 2-substituted benzoquinones and (E)-1-trimethylsilyloxybuta-1,3-diene through a 4a,5 carbon bond fission (Scheme 3) [4]

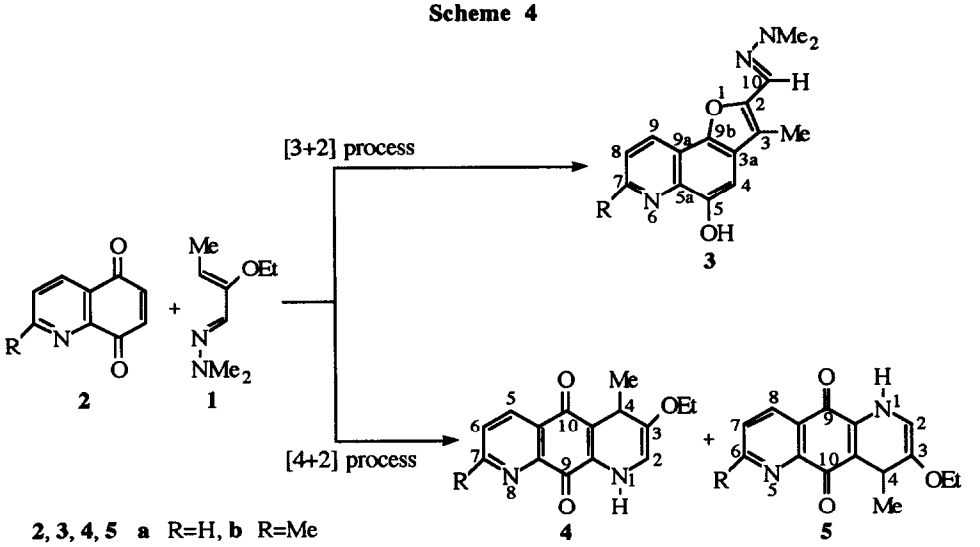
Scheme 3



R=Ac, CHO, CO_2Me, NO_2

As part of our investigation on the cycloaddition reactions of 2-ethoxybut-2-enal N,N-dimethylhydrazone **1** with quinones,[1m] we reported in a preliminary note,[1o] that in a chloroform solution, quinoline-5,8-diones **2** and azadiene **1** gave regiospecifically furoquinoline derivatives **3** (40-43%) through a [3+2] process, while the [4+2] cycloadducts **4+5** were obtained in only 8% overall yield with a respective ratio of 6/4 (Scheme 4)

Scheme 4



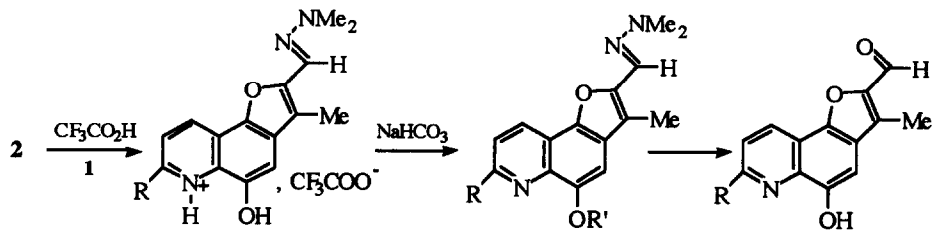
The present work aimed to develop the usefulness of **1** in the synthesis of furoquinoline derivatives and to extend this [3+2] process to naphthoquinones

RESULTS AND DISCUSSION

We have observed that the Diels-Alder reaction between azadiene **1** and quinone **2a** is very sensitive to an acidic medium and oxygen The yields of the [4+2] process were then improved by carrying out this reaction in the absence of any acidic trace and in a deoxygenated toluenic solution of the quinone by nitrogen bubbling for 1h before addition of azadiene **1** Thus, under these conditions compounds **4a+5a** were obtained in 63% yield with the same ratio of the regioisomers (6/4) A complete account of this process will be given in a future paper

In contrast, an optimal yield in the furoquinoline derivative **6a** (Scheme 5) was reached by carrying out the reaction in dichloromethane in the presence of 1 5 equivalent of trifluoroacetic acid The use of acetic or trichloroacetic acids or boron trifluoride etherate gave poorer yields (about 40%) Compound **3a** was then obtained after neutralization of **6a** by a saturated solution of sodium hydrogen carbonate Quinone **2b** gave under similar conditions the trifluoroacetate **6b** and the free base **3b** Treatment of **3a** by acetic anhydride in the presence of pyridine gave the acetate **3c** while hydrolysis of the hydrazone function in **3b** led to the corresponding aldehyde **3d**

Scheme 5



2a R=H
2b R=Me

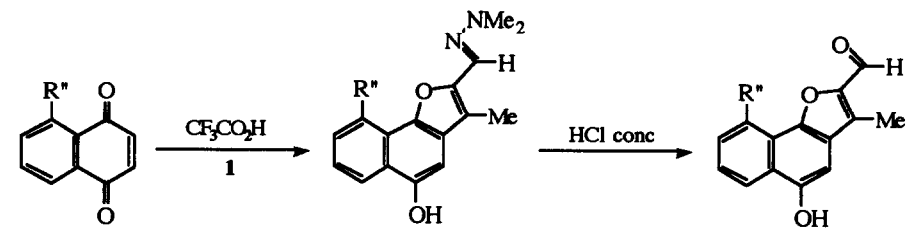
6a R=H (86 %)
6b R=Me (82 %)

3a R=H, R'=H (98 %)
3b R=Me, R'=H (99 %)
3c R=H, R'=Ac (82 %)

3d R=Me (83 %)

When this procedure was applied to naphthoquinones **7**, the naphthofurans **8** were directly obtained Hydrolysis of the hydrazone function in **8a** gave similarly **8c** (Scheme 6)

Scheme 6



7a R"=H
7b R"=OMe
7c R"=OH

8a R"=H (81 %)
8b R"=OMe (48 %)

8c R"=H (86 %)

Starting from juglone **7c**, our attempts to prepare a naphthofuran derivative failed probably due to the presence of the hydroxyl group In this case, we observed the formation of tar products

Structure elucidation of compound **3a**, choosed as model for the furoquinoline derivatives, was demonstrated by the use of mass spectrometry[5] and high field NMR spectroscopy First, the ^{13}C-NMR spectrum recorded with a DEPT technique shows the presence of eight primary or tertiary and seven quaternary carbons Then, both the 1D ^{1}H NOE DIFF and 2D ^{1}H-NMR spectra confirmed the furoquinoline structure and the *s-trans* conformation for the hydrazone or the aldehyde function in compound **3a** or **3d**

Assignment of the regiochemistry was made by a 2D ^{1}H-^{13}C HMBC correlation Indeed, in compound **3a**, H-9 gives three ^{3}J couplings H-9/C-5a, H-9/C-7, H-9/C-9b while in the hypothesis of an opposite regioisomer, H-6 would present three ^{3}J couplings with C-9a, C-8 and C-5 If the spectrum shows the two first interactions (H-6/C-9a, H-6/C-8), the H-6/C-5 correlation is not observed Moreover, the interaction H-6/C-9b, visible on the spectrum, cannot be explained in this wrong structure

Concerning the regioisomer synthesized from 5-methoxy-1,4-naphthoquinone **7b**, a 1D ^{1}H NOE DIFF technique has demonstrated that the structure is **8b** Indeed, irradiation of the hydroxyl proton (δ=9 92 ppm)

gives a response on H-4 (δ=6 94 ppm) and H-6 (δ=7 77 ppm)

The ^{1}H-NMR spectral data of all the other compounds prepared show very close chemical shifts for the H-10, Me-3 and NMe_2 substituents (see the Table) The structures of **6a** and **6b** are also in good agreement with the chemical shifts of these protons Furthermore, the signals of the mobile proton of the hydroxyl groups are not observed, while those of NH^+ gave broad singlets respectively at 4 19 and 4 04 ppm

Table ^{1}H-NMR spectral data of compounds **3**, **6** and **8** (300 Mz, DMSO-d_6, δ ppm)

Compound	OH	H-10	H-4	NMe_2	Me-3
3a	9 44	7 36	7 20	3 00	2 36
3b	9 08	7 35	7 17	2 99	2 34
3c	/	7 37	7 79	3 04	2 40
3d	9 40	9 96	7 26	/	2 59
6a	/	7 36	7 30	3 03	2 37
6b	/	7 36	7 31	3 02	2 37
8a	9 97	7 37	6 92	2 99	2 34
8b	9 92	7 42	6 94	2 99	2 35
8c	10 37	9 99	7 00	/	2 60

Concerning a probable mechanism for the [3+2] process, the fact that the furan compounds are regiospecifically obtained, while a weak regioselectivity is observed in the Diels-Alder reaction agrees with a nucleophilic addition of C-3 of the α,β-unsaturated hydrazone **1** to the more electron deficient carbon of the quinone C-6 of quinoline-5,8-dione[6,7a] and C-3 of 5-methoxy-1,4-naphthoquinone[7b] and invalidates in the present case the hypothesis of a carbon-carbon bond fission from the [4+2] cycloadducts Compounds **6** and **8** were then obtained after a ring closure of the corresponding intermediate followed by a loss of ethanol

CONCLUSION

This work describes the ability of 2-ethoxybut-2-enal N,N-dimethylhydrazone **1** to give with quinoline-5,8-diones, either a weakly regioselective [4+2] cycloaddition or a regiospecific [3+2] process according to the experimental conditions used Thus, in a neutral medium and in the absence of oxygen, dihydro diazaanthraquinones were obtained in good yields, while the use of trifluoroacetic acid provides an efficient route to furoquinoline derivatives When applied to naphthoquinones, this process gave naphthofurans Deprotection of the hydrazone function of **3b** and **8a** led to the carboxaldehydes **3d** and **8c** in excellent yields The structural elucidation of these furan derivatives was made by 2D ^{1}H-^{13}C HMBC and 1D ^{1}H NOE DIFF NMR techniques Their formation involves an initial nucleophilic attack of the more electron deficient carbon of the quinone by C-3 of the α,β-unsaturated hydrazone according to the well known condensation of enamines to benzoquinone in the presence of an acidic medium [8]

EXPERIMENTAL SECTION

Melting points were taken in capillary tube using a Büchi 510 apparatus The infra-red spectra were performed on a Perkin-Elmer 1310 spectrophotometer High resolution mass spectra were performed by direct ionisation (EI at 70 eV) on a AE1 MS 902 apparatus Elemental analysis were made at the Centre de Microanalyse du CNRS at Vernaison, France

All NMR spectra were performed on a Bruker AM 300 spectrometer About 10mg of the compound were dissolved in 0 5 ml of DMSO-d_6 For ^1H NOE DIFF experiments, the numerical resolution was maintained to about 0 1 Hz/point, the presaturation time and the power $\gamma B1/2\pi$ of the decoupler were respectively fixed to 4s and 10 Hz The 2D ^1H-^{13}C HMBC technique was performed with the INVDR2LP AU Bruker sequence The J filter and the transfer time for long range coupling were fixed respectively to 160 Hz and 8 Hz The acquisition parameters were AQ = 9213 s, SW2 = 2403 Hz, SI = 1024, NE = 512, NS = 48 and SW1 = 11702 Hz Prior to the FFT, the signal was weighted by a none shifted sinbell in the two dimensions The size of the final matrix was 1k.1k

Azadiene **1**[2], azanaphthoquinone **2a**, **2b**[9] and naphthoquinones **7b**[10] were prepared according to procedures described in the literature

1,8-Diaza-3-ethoxy-1,4-dihydro-4-methyl-9,10-anthraquinone 4a and 1,5-diaza-3-ethoxy-1,4-dihydro-4-methyl-9,10-anthraquinone 5a[10]

A solution of azadiene **1** (0 365 g, 2 35 mmol) in 5 ml of toluene (freshly distilled under nitrogen), deoxygenated by nitrogen bubbling for 1 h was added to quinoline-5,8-dione **2a** (0 15 g, 0 94 mmol) in the same solvent (10 ml) at room temperature under stirring and nitrogen atmosphere At the end of the addition (15 min), the solvent was evaporated under vacuum and the blue regioisomers (**4a/5a** 60/40) were purified and separated by chromatography (1 1, hexane-AcOEt) Overall yield 0 16 g, 63 % **4a** M p 155°C, IR (KBr) ν 3335 (NH), 1700 (9-CO), 1655 (10-CO) cm^{-1}, ^1H-NMR ($CDCl_3$, 300 MHz) δ ppm 8 89 (dd, 1H, J=4 6 and 1 5 Hz, H-7), 8 44 (dd, 1H, J=7 8 and 1 5 Hz, H-5), 7 64 (dd, 1H, J=7 8 and 4 6 Hz, H-6), 6 91 (br s, 1H, NH), 5 65 (d, 1H, J=4 8 Hz, H-2), 3 98 (q, 1H, J=6 6 Hz, H-4), 3 78 (dq, 2H, J=3 0 and 7 0 Hz, CH_2), 1 36 (t, 3H, J=7 0 Hz, CH_3), 1 30 (d, 3H, J=6 6 Hz, CH_3-4), Anal Calcd for $C_{15}H_{14}N_2O_3$ C, 66 66, H, 5 22, N, 10 36 Found C, 66 94, H, 4 99, N, 10 23 **5a** M p 174°C, IR (KBr) ν 3345 (NH), 1685 (9-CO and 10-CO) cm^{-1}, ^1H-NMR ($CDCl_3$, 300 MHz) δ ppm 9 00 (d, 1H, J=4 9 Hz, H-6), 8 33 (d, 1H, J=7 9 Hz, H-8), 7 54 (dd, 1H, J=7 9 and 4 9 Hz, H-7), 6 78 (br s, 1H, NH), 5 66 (d, 1H, J=4 6 Hz, H-2), 4 04 (q, 1H, J=6 6 Hz, H-4), 3 78 (q, 2H, J=7 0 Hz, CH_2), 1 36 (t, 3H, J=7 0 Hz, CH_3), 1 31 (d, 3H, J=6 6 Hz, CH_3-4), Anal Calcd for $C_{15}H_{14}N_2O_3$ C, 66 66, H, 5 22, N, 10 36 Found C, 66 67, H, 5 00, N, 10 14

5-Hydroxy-3-methylfuro[3,2-*f*]quinolinium-2-carboxaldehyde N,N-dimethylhydrazone, trifluoroacetate 6a

Quinoline-5,8-dione **2a** (0 3 g, 1 9 mmol) was dissolved in anhydrous dichloromethane (5 ml) This solution was cooled to 0°C and trifluoroacetic acid (0 22 ml, 2 85 mmol) was added The mixture was stirred at room temperature for 15 min Then, azadiene **1** (0 59 g, 3 8 mmol) in 3 ml of the same solvent was added slowly and the mixture allowed to stand at room temperature for 5 h Removing of the solvent under vacuum left a residue which gave by trituration with anhydrous ether (3 ml) an orange precipitate of **6a** It was recrystallized from ethanol (0 625 g, 86 %) M p 194°C, IR (KBr) ν 1675 (trifluoroacetate anion) cm^{-1}, ^1H-NMR (DMSO-d_6, 300 MHz) δ ppm 8 88 (dd, 1H, J=4 6 and 1 4 Hz, H-7), 8 78 (dd, 1H, J=8 4 and 1 4 Hz, H-9), 7 80 (dd, 1H, J=8 4 and 4 6 Hz, H-8), 7 36 (s, 1H, H-10), 7 30 (s, 1H, H-4), 4 19 (br s, 1H, NH^+), 3 03 (s, 6H, $N(CH_3)_2$), 2 37 (s, 3H, CH_3-3) Anal Calcd for $C_{17}H_{16}F_3N_3O_4$ C, 53 27, H, 4 21, F, 14 87, N, 10 96 Found C, 52 99, H, 4 21, F, 14 83, N, 11 11

5-Hydroxy-3,7-dimethylfuro[3,2-*f*]quinolinium-2-carboxaldehyde N,N-dimethylhydrazone, trifluoroacetate 6b

Following the procedure used to prepare **6a**, compound **6b** was obtained from azadiene **1** and 2-methylquinoline-5,8-dione **2b** (0 568 g, 82 %) M p 170°C, IR (KBr) ν 1675 (trifluoroacetate anion) cm^{-1}, ^1H-NMR (DMSO-d_6, 300 MHz) δ ppm 8 76 (d, 1H, J=8 8 Hz, H-9), 7 74 (d, 1H, J=8 8 Hz, H-8), 7 36 (s, 1H, H-10), 7 31 (s, 1H, H-4), 4 04 (br s, 1H, NH^+), 3 02 (s, 6H, $N(CH_3)_2$), 2 84 (s, 3H, CH_3-7), 2 37 (s, 3H,

CH_3-3) Anal Calcd for $C_{18}H_{18}F_3N_3O_4$. C, 54 41, H, 4 57, F, 14 34, N, 10 57 Found C, 54 59, H, 4 47, F, 14 53, N, 10 30

5-Hydroxy-3-methylfuro[3,2-*f*]quinoline-2-carboxaldehyde N,N-dimethylhydrazone, 3a[10]

A solution of compound **6a** (0 3 g, 0 78 mmol) in water (5 ml) was neutralized by a saturated aqueous solution of sodium hydrogen carbonate The yellow precipitate formed was washed with water and dried Its recrystallization from ethanol gave the furoquinoline derivative **3a** (0 206 g, 98 %) M p 168°C, IR (KBr) ν 3125–3550 (OH) cm^{-1}, ^{1}H-NMR (DMSO-d_6, 300 MHz) δ ppm 9 44 (s, 1H, OH), 8 82 (dd, 1H, J=4 2 and 1 6 Hz, H-7), 8 55 (dd, 1H, J=8 4 and 1 6 Hz, H-9), 7 62 (dd, 1H, J=8 4 and 4 2 Hz, H-8), 7 36 (s, 1H, H-10), 7 20 (s, 1H, H-4), 3 00 (s, 6H, $N(CH_3)_2$), 2 36 (s, 3H, CH_3-3), ^{13}C-NMR (DMSO-d_6, 300 MHz) δ ppm 8 16 (CH_3-3), 42 70 ($N(CH_3)_2$), 101 41 (C-4), 112 69 (C-3), 115 95 (C-9a), 121 67 (C-10), 122 47 (C-8), 126 66 (C-3a), 128 36 (C-9), 136 96 (C-5a), 140,84 (C-9b), 146 78 (C-7), 149 45 (C-5), 150 34 (C-2) Anal Calcd for $C_{15}H_{15}N_3O_2$, 0 2 H_2O C, 66 02, H, 5 69, N, 15 40 Found C, 66 27, H, 5 70, N, 15 34 HRMS Calcd for $C_{15}H_{15}N_3O_2$ 269 1166 Found 269 1172

5-Hydroxy-3,7-dimethylfuro[3,2-*f*]quinoline-2-carboxaldehyde N,N-dimethylhydrazone, 3b[10]

Following the procedure used to prepare **3a**, compound **3b** was obtained from derivative **6b** and recrystallized from ethanol (0 212 g, 99 %) M p 127°C, IR (KBr) ν 3250–3400 (OH) cm^{-1}, ^{1}H-NMR (DMSO-d_6, 300 MHz) δ ppm 9 08 (s, 1H, OH), 8 25 (d, 1H, J=8 6 Hz, H-9), 7 53 (d, 1H, J=8 6 Hz, H-8), 7 35 (s, 1H, H-10), 7 17 (s, 1H, H-4), 2 99 (s, 6H, $N(CH_3)_2$), 2 71 (s, 3H, CH_3-7), 2 34 (s, 3H, CH_3-3), ^{13}C-NMR (DMSO-d_6, 300 MHz) δ ppm 8 24 (CH_3-3), 24 99 (CH_3-7), 42 81 N-$(CH_3)_2$), 101 24 (C-4), 112 84 (C-3), 114 14 (C-9a), 121 95 (C-10), 123 20 (C-8), 125 25 (C-3a), 128 76 (C-9), 136 39 (C-5a), 141,23 (C-9b), 148 76 (C-5), 149 95 (C-2), 155 54 (C-7) Anal Calcd for $C_{16}H_{17}N_3O_2$, 0 2 H_2O C, 66 98, H, 6 11, N, 14 64 Found C, 66 66, H, 5 99, N, 14 63 HRMS Calcd for $C_{16}H_{17}N_3O_2$ 283 1321 Found 283 1330

5-Acetoxy-3-methylfuro[3,2-*f*]quinoline-2-carboxaldehyde N,N-dimethylhydrazone, 3c

To a stirred solution of **3a** (0 2 g, 0 74 mmol) in dichloromethane (20 ml), pyridine (0 59 g, 7 4 mmol) and acetic anhydride (0 38 g, 3 7 mmol) were successively added. Stirring was maintained at room temperature for 24 h, then, the mixture was treated with methanol (10 ml) After 1 5 h of additional stirring, the mixture was partitioned between diethyl ether (60 ml) and water (30 ml) The organic layer was washed with water (3 x 20 ml) and evaporated Recrystallization of the yellow residue from ethanol gave the acetate **3c** (0 19 g, 82 %) M p 156°C, IR (KBr) ν 1760 (C=O) cm^{-1}, ^{1}H-NMR (DMSO-d_6, 300 MHz) δ ppm 8 87 (dd, 1H, J=4 2 and 1 6 Hz, H-7), 8 63 (dd, 1H, J=8 4 and 1 6 Hz, H-9), 7 79 (s, 1H, H-4), 7 67 (dd, 1H, J=8 4 and 4 2 Hz, H-8), 7 37 (s, 1H, H-10), 3 04 (s, 6H, $N(CH_3)_2$), 2 42 (s, 3H, $OCOCH_3$), 2 40 (s, 3H, CH_3-3), Anal Calcd for $C_{17}H_{17}N_3O_3$ C, 65 58, H, 5 50, N, 13 50 Found C, 65 32, H, 5 62, N, 13 68 HRMS Calcd for $C_{17}H_{17}N_3O_3$ 311 1270 Found 311 1275

5-Hydroxy-3,7-dimethylfuro[3,2-*f*]quinoline-2-carboxaldehyde 3d

Furoquinoline **3b** (0 2 g, 0 71 mmol) in a 15 % aqueous HCl solution (10 ml) was heated to reflux for 2 h Then, the reaction mixture was poured into cold water (40 ml) and neutralized with sodium hydrogen carbonate The aldehyde **3d** was isolated as a green precipitate It gives after recrystallization from ethanol a yellow powder (0,14 g, 83 %) M p 203°C, IR (KBr) ν 3360 (OH), 1680 (CO) cm^{-1}, ^{1}H-NMR (DMSO-d_6, 300 MHz) δ ppm 9 96 (s, 1H, CHO), 9 44 (s, 1H, OH), 8 55 (d, 1H, J=7 5 Hz, H-9), 7 61 (d, 1H, J=7 5 Hz, H-8), 7 26 (s, 1H, H-4), 2 74 (s, 3H, CH_3-7), 2 59 (s, 3H, CH_3-3), Anal Calcd for $C_{14}H_{11}NO_3$ C, 69 70, H, 4 60, N, 5 81 Found C, 69 51, H, 4 81, N, 5 84

5-Hydroxy-3-methylnaphtho[1,2-*b*]furan-2-carboxaldehyde N,N-dimethylhydrazone 8a

Following the procedure used to prepare **6a**, compound **8a** was directly obtained as a grey powder from azadiene **1** and 1,4-naphthoquinone **7a** (0 41 g, 81 %) M p 263°C, IR (KBr) ν 3080–3400 (OH) cm^{-1}, ^{1}H-NMR (DMSO-d_6, 300 MHz) δ ppm 9 97 (s, 1H, OH), 8 19 (d, 1H, J=8 2 Hz, H-6 or H-9), 8.09 (d, 1H, J=8 2 Hz, H-6 or H-9), 7 59 (t, 1H, J=8 2 Hz, H-7 or H-8), 7 45 (t, 1H, J=8 2 Hz, H-7 or H-8),7 37 (s, 1H,

H-10), 6 92 (s, 1H, H-4), 2 99 (s, 6H, $N(CH_3)_2$), 2 34 (s, 3H, CH_3-3) Anal Calcd for $C_{16}H_{16}N_2O_2$ C, 71 62, H, 6 01, N, 10 44 Found C, 71 50, H, 5 97, N, 10 48

5-Hydroxy-9-methoxy-3-methylnaphtho[1,2-*b*]furan-2-carboxaldehyde N,N-dimethylhydrazone 8b

Following the procedure used to prepare **6a**, compound **8b** was directly obtained as a grey powder from azadiene **1** and 5-methoxy-1,4-naphthoquinone **7b** (0 228 g, 48 %) M p 179°C, IR (KBr) ν 3080–3300 (OH) cm^{-1}, ^{1}H-NMR (DMSO-d_6, 300 MHz) δ ppm 9 92 (s, 1H, OH), 7 77 (d, 1H, J=8 7 Hz, H-6), 7 42 (s, 1H, H-10), 7 36 (dd, 1H, J=8 7 and 8 1 Hz, H-7), 7 08 (d, 1H, J=8 1 Hz, H-8), 6 94 (s, 1H, H-4), 3 99 (s, 3H, CH_3O), 2 99 (s, 6H, $N(CH_3)_2$), 2 35 (s, 3H, CH_3-3) Anal Calcd for $C_{17}H_{18}N_2O_3$, 1 H_2O C, 64 54, H, 6 37, N, 8 85 Found C, 64 90, H, 6 35, N, 8 89

5-Hydroxy-3-methylnaphtho[1,2-*b*]furan-2-carboxaldehyde 8c

A suspension of naphthofuran **8a** (0 2 g, 0,75 mmol) in 10 ml of concentrated HCl was sonicated for 1 5 h in a thermostated Labsonic U apparatus (20°C, 4 mm diameter probe and 45 W electrical input) The yellow precipitate of the aldehyde **8c** was separated by filtration and recrystallized from CH_2Cl_2 (0 145 g, 86 %) M p 195°C, IR (KBr) ν 3300 (OH), 1665 (CO) cm^{-1}, ^{1}H-NMR (DMSO-d_6, 300 MHz) δ ppm 10 37 (s, 1H, OH), 9 99 (s, 1H, CHO), 8 28 (d, 1H, J=8 1 Hz, H-6 or H-9), 8 25 (d, 1H, J=8.1 Hz, H-6 or H-9), 7 73 (t, 1H, J=8 1 Hz, H-7 or H-8), 7 66 (t, 1H, J=8 1 Hz, H-7 or H-8) 7 (s, 1H, H-4), 2 6 (s, 3H, CH_3-3), Anal Calcd for $C_{14}H_{10}O_3$, 0 4 H_2O C, 72 03, H, 4 63 Found C, 71 95, H, 4 28

ACKNOWLEDGEMENTS: We thank Région Rhône-Alpes for a financial support and Université Claude Bernard for a help on NMR program

REFERENCES AND NOTES

1 For examples on their synthetic applications, see (*a*) Sainte, F , Serckx-Poncin, B , Hesbain-Frisque, A -M , Ghosez, L , *J Am. Chem Soc.*, **1982**, *104*, 1428-1430, (*b*) Potts, K T , Battachargee, D , Walsh, E. B , *J. Chem. Soc. Chem. Commun.*,**1984**, 114-115, (*c*) Tamura, Y , Tsugoshi, T , Nakajima, Y , Kita, Y , *Synthesis*, **1984**, *11*, 930-933, (*d*) Ghosez, L , Serckx-Poncin, B , Rivera, M , Bayard, P , Sainte, F , Demoulin, A , Frisque-Hesbain, A -M , Mockel, A , Munoz, L , Bernard-Henriet, C , *Lect. Heterocycl., Chem* , **1985**, *8*, 69-78, (*e*) Potts, K T , Walsh, E. B , Battachargie, D , *J. Org. Chem.*, **1987**, *52*, 2285-2292, (*f*) Walden, A , *Helv Chim Acta*, **1988**, *71*, 486-492, (*g*) Walden, A , *Helv Chim. Acta*, **1988**, *71*, 493-497, (*h*) Chigr, M , Fillion, H , Rougny, A , *Tetrahedron Lett.*, **1988**, *29*, 5913-5916, (*i*) Dolle, R. E., Armstrong, W P , Shaw, A N , Novelli, R , *Tetrahedron Lett.*, **1988**, *29*, 6349-6352, (*j*) Gesto, C , De la Cuesta, E., Avendano, C , *Tetrahedron*, **1989**, *45*, 4477-4484, (*k*) Walden, A , *Helv Chim. Acta*, **1989**, *72*, 1435-1443, (*l*) Echavarren, A M , *J. Org. Chem.*, **1990**, *55*, 4255-4260, (*m*) Nebois, P , Barret, R , Fillion, H , *Tetrahedron Lett.*, **1990**, *31*, 2569-2572, (*n*) Lee, H , Anderson, W K , *Tetrahedron Lett* , **1990**, *31*, 4405-4408, (*o*) Nebois, P , Fillion, H , *Tetrahedron Lett.*, **1991**, *32*, 1307-1310, (*p*) Koldobskii, A B , Lunin, V V , Voznesenskii, S A , *J. Org Chem. USSR*, **1992**, *8*, 620-634, (*q*) Biswas, G K , Nath, A C , Mukherjee, B , Patra, A , Chakrabarty, M , *Tetrahedron Lett.*, **1992**, *33*, 117-118, (*r*) Valderrama, J A , Pessoa-Mahana, H , Tapia, R , *J Heterocycl Chem* , **1992**, 1177-1180

2 Severin, T , Wanninger, G , Lerche, H , *Chem. Ber* , **1984**, *117*, 2875-2885

3 Potts, K. T , Walsh, E B , *J Org Chem.*, **1988**, *53*, 1199-1202

4 Farina, F , Paredes, M C , Valderrama, J A , *J. Chem. Soc Perkin Trans 1*, **1990**, 2345-2346

5 Nebois, P , Fillion, H , Ulrich, J , *Org Mass Spectrometry*, **1991**, *26*, 1125-1126

6 Pratt, Y T , Drake, N L , *J Amer Chem Soc* , **1960**, *82*, 1155-1161

7 (*a*) Cameron, D W , Deutscher, K R , Feutrill, G I , *Aust J Chem.*, **1982**, *35*, 1439-1450, (*b*) Cameron, D W , Crossley, M J , Feutrill, G I , Griffiths, P G , *Aust J Chem.*, **1978**, *31*, 1335-1352

8 Domschke, G , *J Prakt Chem* , **1966**, *32*, 144-157

9 Barret, R , Daudon, M , *Tetrahedron Lett* , **1990**, *31*, 4871-4872

10 Garden, J F , Thomson, R H , *J Chem Soc* , **1957**, 2483-2489