BASE-CATALYZED ELECTROPHILIC SUBSTITUTION IN 2(1*H*)-QUINOLINONES

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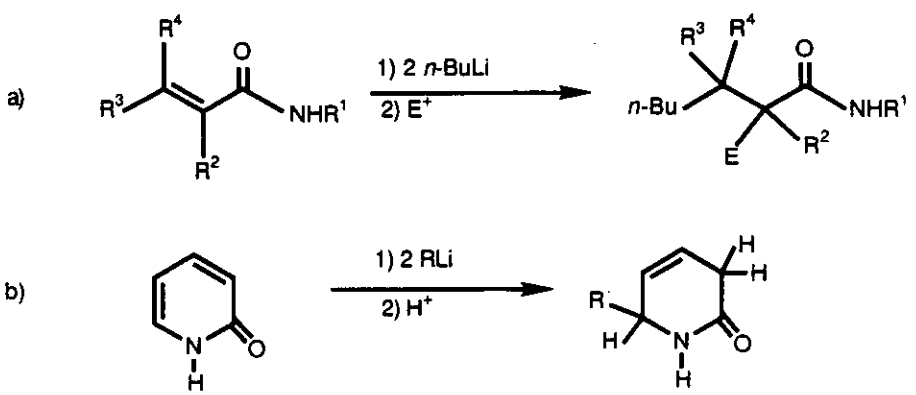
Abstract - Instead of tandem conjugate addition-α-alkylation to C_3=C_4 double bond of 2(1H)- quinolinones, regioselective C_3-lithiation and subsequent C_3-alkylation takes place by reaction with two equivalents of n-butyllithium and several electrophiles.

INTRODUCTION

Several examples of tandem conjugate addition-α-alkylation reactions in acrylanilides,[1] cinnamamides,[2] and 5,6-dihydro-2-pyridones[3] have been described and found synthetic utility (Scheme 1,a). Pyridone itself is able to add nucleophiles to the 6-position[4] (Scheme 1,b). As we are interested in the preparation of 1*H*-quinoline-2,5,8-trione derivatives as dienophiles in diazaquinomicin A analogues synthesis,[5,6] we investigated base-catalyzed alkylation reactions of 2(1*H*)-quinolinone as a model substrate to obtain C_4-alkyl or C_3, C_4-dialkyl derivatives using a methodology analogous to that described by Baldwin *et al.*[1] for conjugate addition in acrylanilides.



Scheme 1

RESULTS

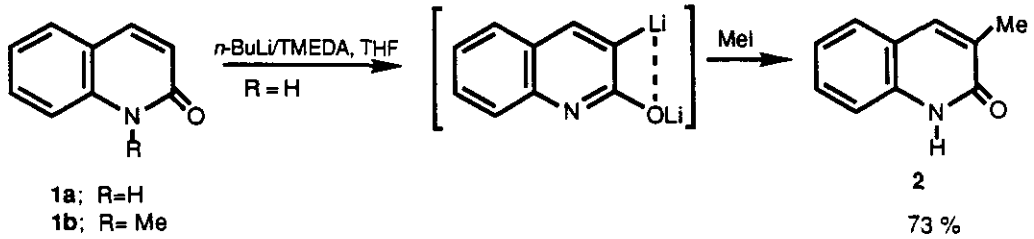
Treatment of 2(1*H*)-quinolinone (**1a**) with 2 equiv. of *n* -butyllithium/TMEDA (THF) gave a red solution which was quenched with methyl iodide. Surprisingly enough, 3-methyl-2(1*H*)-quinolinone (**2**) was obtained after acid treatment (73% yield, Scheme 2).

Literature about base-catalyzed electrophilic substitutions in quinolines showed that the first indirect method to obtain 3-alkyl-2(1*H*)-quinolinones, was reported in 1971 by Narasimhan *et al.*[7] The poor *ortho*-directing effect of 2-ethoxy or 2,4-dimethoxy substituents was used to assist the regioselective *ortho*-lithiation in C_3-position, being finally, the 2-alkoxy substituent selectively hydrolyzed to 2-hydroxy compounds.

Other substituents in the 2-position of quinoline used as *ortho*-lithiation directing groups for subsequent trapping of the C_3-lithiated intermediate with electrophiles, have been; *N*,*N*-dialkylcarbamates, (with limited synthetic value due to competitive anionic rearrangements),[8] 2-fluoro,[9] 2-chloro,[10] and 2-pivaloylamino.[11]

Formation of compound (**2**) implies a new regioselective C_3-lithiation reaction due to the *ortho*-directing effect of 2-quinolinone lithium salt and therefore an O, C_3-dianion associated with two lithium cations is proposed as the reactive intermediate.

According to this interpretation, the regioselectivity was lost when the reaction was run in analogous conditions with *N*-methyl-2(1*H*)-quinolinone (**1b**) for which a complex mixture of unidentified products (up to six by tlc) was obtained.



Scheme 2

It is known that the oxygen atom of lithium phenoxide may still coordinate with an organolithium reagent, facilitating dianion formation to give *ortho*-substituted phenols in 42-48 % yield.[12] However, the presence of a *N*-hydrogen in *N*-unsubstituted pyridone was suposed "to lead to an unreactive anion", and protection of the pyridone lithium salt with CO_2 prior to C-lithiation was considered necessary.[13] So, we have the first experimental evidence about the possibility of direct functionalization of 2(1*H*)-

quinolinone in the C_3-position.

The scope of the reaction has been studied extending the range of electrophiles to carbonyl compounds, trimethylsilyl chloride (Table 1) and some acylating reagents (Table 2).

Electrophile	Product	Yield (%)[a]
MeI	**2**	73
C_6H_5-CHO	**3**	26
4-(CH_3O)-C_6H_4-CHO	**4**	23
4-F-C_6H_4-CHO	**5**	25
2-F-C_6H_4-CHO	**6**	27
4-Cl-C_6H_4-CHO	**7**	25
2-Cl-C_6H_4-CHO	**8**	26
C_6H_5-CO-C_6H_5	**9**	18
Me_3SiCl	**10**	56

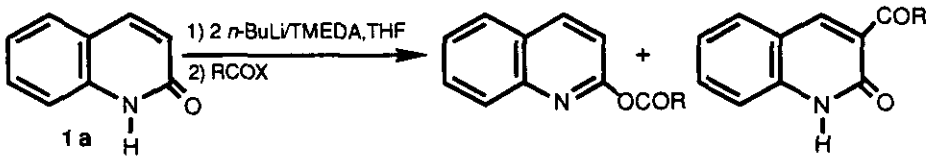
[a] For isolated and purified products.

Table 1. One-pot synthesis of 3-substituted 2(1*H*)-quinolinones.

The moderate yields found with aldehydes and ketones (compounds (**3-9**)) could reflect competition between alkylation on carbon and oxygen, leading in this case to a hemiketal, which reverts to starting quinolinone on work-up. Similarly, a *O*-sililated compound could be also formed, lowering the yield of the C-substituted product (**10**). In the case of methyl iodide, such a competition does not exist, since the 2-methoxyquinoline (**11**), obtained by methylation of the 2(1*H*)-quinolinone silver salt (see experimental), was stable to the acid work-up conditions.

For acylating reagents, the *O*-acylated compounds were the main products (**12** and **13**, Table 2), although in the case of ethyl chloroformate some C-substituted compound (**14**) was isolated. As it would be expected, CO_2 exclusively gave the 3-substituted acid (**15**).

Although other electrophiles have to be tried and effects of counterion, solvent additives etc. studied, we have shown that OLi in 2-hydroxyquinoline lithium salt is an effective *ortho* -lithiation directing group, which permits regioselective functionalization of 2(1*H*)-quinolinone in one-pot reactions.



	O-Substituted		3-Substituted	
RCOX	product	Yield (%)[a]	product	Yield (%)[a]
C_6H_5COCl	**12**	45	--	0
EtOCOCl	**13**	30	**14**	4
CO_2	--	0	**15**	11[b]

[a] For isolated and purified products. [b] ^{1}H-Nmr yield.

Table 2 - Reaction with acylating reagents.

EXPERIMENTAL

Ir spectra were recorded on a Perkin-Elmer 577 spectrophotometer. Nmr spectra were obtained on a Varian VXR-300 (300 MHz for ^{1}H and 75.4 MHz for ^{13}C), using $CDCl_3$ or DMSO-d_6 as solvents, and TMS as internal standard. * Denotes interchangeable assignments. Elemental analyses were determined on a Perkin-Elmer 2400 CHN microanalyzer. Melting points were measured in open capillary tubes, *using a Büchi immersion apparatus*, and are uncorrected. Separations by column chromatography were performed on silica gel (SDS 60 ACC, 230-400-mesh). All reagents were of commercial precedence (*Aldrich, Merck, Probus*) and were used as received, except aromatic aldehydes which were distilled prior to use. THF was freshly distilled from sodium and benzophenone.

1-Methyl-2(1*H*)-quinolinone (**1b**). To a stirred solution of 2(1*H*)-quinolinone (1 g, 6.9 mmol) in absolute ethanol (25 ml), a solution of sodium ethoxide, prepared from sodium (0.25 g, 1.08 mmol) and ethanol (125 ml), was added. *Stirring* was continued at room temperature for 12 h, and then, the solvent was eliminated, and the dried residue was heated in dry DMF (100 ml) with an excess of methyl iodide (25.8 g, 181.7 *mmol*) for 12 h at 40 °C. The solvent was evaporated and the yellowish residue was extracted with chloroform. The organic layer was washed with 25 % ammonia and water, dried over *sodium sulphate, and the solvent was evaporated.* The crude product was crystallized from petroleum ether. Yield, 0.78 g (70 %); mp 67-68 °C (lit.,[14] mp 68-69 °C from petroleum ether, and lit.,[15] mp 73-74 °C). ^{1}H-Nmr ($CDCl_3$) δ: 7.64 (1H, d, J=9.6 Hz, C_4-H), 7.60-7.50 (2H, m, C_5-H, C_7-H), 7.34 (1H, d, J= 8.4 Hz, C_8-H), 7.21 (1H, m, C_6-H), 6.68 (1H, d, J= 9.6 Hz, C_3-H), 3.69 (3H, s, CH_3). ^{13}C-Nmr ($CDCl_3$) δ: 162.0 (C_2), 139.8 (C_{8a}), 138.6 (C_4), 130.3 (C_7), 128.5 (C_5), 121.8, 121.5,

120.4 (C_{4a}), 113.8 (C_8), 29.1 (CH_3).

2-Methoxyquinoline (**11**). A mixture of 2(1*H*)-quinolinone (1 g, 6.9 mmol), silver oxide (0.83 g, 3.5 mmol) and methyl iodide (25.4 g, 178 mmol) in dry chloroform (100 ml) was refluxed in the darkness for 96 h. After being cooled, the inorganic material was filtered, and the solvent was evaporated. Column chromatography of the residue on silica gel eluting with ethyl acetate-hexane (1:1) afforded **11** (lit.,[16] bp 246-47 °C) as a light oil (0.78 g, 71 % yield), and a small ammount (0.08 g, 8 %) of compound (**1b**). ^{1}H-Nmr ($CDCl_3$) δ: 8.00 (1H, d, J= 8.8 Hz, C_8-H), 7.85 (1H, d, J= 8.8 Hz, C_4-H), 7.64 (2H, m, C_5-H and C_7-H), 7.36 (1H, m, C_6-H), 6.90 (1H, d, J= 8.8 Hz, C_3-H), 4.13 (3H, s, OCH_3). ^{13}C-Nmr ($CDCl_3$) δ: 162.1 (C_2), 146.4 (C_{8a}), 138.3 (C_4), 129.2, 127.2, 127.0, 124.8 (C_{4a}), 123.7, 112.8 (C_3), and 53.0 (CH_3O).

Lithiation of 2(1*H*)-Quinolinone and Subsequent Quenching with Electrophiles. General Procedure.

A solution of BuLi (9.8 ml of 1.6 M solution in hexane, 15.7 mmol) and TMEDA (3.4 ml, 22.5 mmol) in dry THF (25 ml) prepared at -70 °C and warmed to 0 °C, was added in small portions *via* syringe to a suspension of 2(1*H*)-quinolinone (1 g, 6.9 mmol) in THF (25 ml) kept at -70 °C in nitrogen atmosphere. When the addition was complete, the reaction mixture was warmed to 0-5 °C for 2 h and the resulting red solution was quenched with the electrophile (8-10 mmol) and stirred at room temperature for 15-30 min. The reaction mixture was diluted with chloroform, washed sequentially with 6N hydrochloric acid, aqueous sodium bicarbonate (10 %) and sodium chloride (30 %) solutions, dried over sodium sulphate, and the solvent was evaporated. Compounds (**2-10**) and (**12-15**) were isolated by column chromatography on silica gel using as eluents mixtures of dichloromethane or hexane with ethyl acetate.

3-Methyl-2(1*H*)-quinolinone (**2**). mp 239-240 °C (chloroform) (lit.,[17] mp 234 °C). Ir (KBr): 3500-2600, 1650 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 11.70 (1H, s, NH), 7.73 (1H, s, C_4-H), 7.54 (1H, dd, J= 8.1 and 1.2 Hz, C_5-H), 7.40 (1H, m, C_7-H), 7.26 (1H, d, J=8.1 Hz, C_8-H), 7.12 (1H, m, C_6-H), 2.06 (3H, s, CH_3). ^{13}C-Nmr (DMSO-d_6) δ: 162.7 (C_2), 137.9 (C_{8a}), 136.7 (C_4), 130.0 (C_3), 129.3 (C_7), 127.1 (C_5), 121.9 (C_6), 119.7 (C_{4a}), 114.9 (C_8), 16.5 (CH_3).

3-(α-Hydroxybenzyl)-2(1*H*)-quinolinone (**3**). mp 203-204 °C (acetone). Anal. Calcd for $C_{16}H_{13}NO_2$: C, 76.47; H, 5.21; N, 5.57. Found: C, 76.75; H, 5.25; N, 5.46. Ir (KBr): 3500-2500, 1650 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 11.79 (1H, s, NH), 8.07 (1H, s, C_4-H), 7.73 (1H, d, J= 7.9 Hz, C_5-H), 7.49-7.38 (3H, m, C_7-H, $C_{2'}$-H, $C_{6'}$-H), 7.30-7.10 (5H, m, C_8-H, C_6-H, $C_{3'}$-H, $C_{4'}$-H, $C_{5'}$-H), 5.90 (1H, d, J=3.9 Hz, OH), 5.84 (1H, d, J= 3.9 Hz, CH). ^{13}C-Nmr (DMSO-d_6) δ: 161.1 (C_2), 144.2 ($C_{1'}$), 138.0 (C_{8a}), 137.0 (C_3), 134.4 (C_4), 129.9 (C_7), 128.1 (3 Ph-C), 127.1 (C_5), 126.9 (2 Ph-C), 122.1 (C_6), 119.4 (C_{4a}), 115.0 (C_8).

3-(α-Hydroxy-4-methoxybenzyl)-2(1*H*)-quinolinone (**4**). mp 186-187 °C (ethyl acetate). Anal. Calcd for $C_{17}H_{15}NO_3$: C, 72.58; H, 5.37; N, 4.98. Found: C, 72.40; H, 5.31; N, 4.82. Ir (KBr): 3600-

2600, 1640 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 11.76 (1H, s, exchanges with D_2O, NH), 8.04 (1H, s, C_4-H), 7.73 (1H, dd, J= 7.9 and 1 Hz, C_5-H), 7.45 (1H, m, C_7-H), 7.32 (2H, d, J=8.7 Hz, $C_{2'}$-H, $C_{6'}$-H), 7.29 (1H, d, C_8-H, overlapped with the above signal), 7.17 (1H, m, C_6-H), 6.84 (2H, d, J= 8.7 Hz, $C_{3'}$-H, $C_{5'}$-H), 5.76 (2H, s, CH, OH, exchanges in part with D_2O), 3.71 (3H, s, OCH_3). ^{13}C-Nmr (DMSO-d_6) δ: 160.7 (C_2), 158.1($C_{4'}$), 137.7 (C_{8a}), 137.0 (C_3), 135.9 ($C_{1'}$), 133.7 (C_4), 129.5 (C_7), 127.8 ($C_{2'}$, $C_{6'}$), 127.7 (C_5), 121.7 (C_6), 119.1 (C_{4a}), 114.6 (C_8), 113.1 ($C_{3'}$, $C_{5'}$), 68.4 (C-OH), 54.9 (OCH_3).

3-(α-Hydroxy-4-fluorobenzyl)-2(1*H*)-quinolinone (**5**). mp 182-183 °C (ethanol). Anal. Calcd for $C_{16}H_{12}NO_2F$: C, 71.37; H, 4.49; N, 5.20. Found: C, 71.20; H, 4.78; N, 4.90. Ir (KBr): 3600-2700, 1660 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 11.80 (1H, s, exchanges with D_2O, NH), 8.05 (1H, s, C_4-H), 7.72 (1H, d, J= 7.5 Hz, C_5-H), 7.42-7.47 (3H, m, C_7-H, $C_{2'}$-H, $C_{6'}$-H), 7.30 (1H, d, J= 8.1 Hz, C_8-H), 7.17 (1H, t, J= 7.5 Hz, C_6-H), 7.01 (2H, t, J= 8.7 Hz, $C_{3'}$-H, $C_{5'}$-H), 5.88 (1H, d, J= 4.1 Hz, exchanges with D_2O, OH), 5.80 (1H, d, J= 4.1 Hz, CH). ^{13}C-Nmr (DMSO-d_6) δ: 161.5 ($C_{4'}$, J_{CF}= 242 Hz), 160.7 (C_2), 140.1 ($C_{1'}$, J_{CF}= 3 Hz), 137.8 (C_{8a}), 136.6 (C_3), 134.0 (C_4), 129.6 (C_7), 128.5 ($C_{2'}$, $C_{6'}$, J_{CF}= 8 Hz), 127.8 (C_5), 121.7 (C_6), 119.1 (C_{4a}), 114.6 (C_8), 114.5 ($C_{3'}$, $C_{5'}$, J_{CF}= 21 Hz), 68.2 (C-OH).

3-(α-Hydroxy-2-fluorobenzyl)-2(1*H*)-quinolinone (**6**). mp 175-176 °C (ethyl acetate-hexane). Anal. Calcd for $C_{16}H_{12}NO_2F$: C, 71.37; H, 4.49; N, 5.20. Found: C, 70.94; H, 4.68; N, 4.95. Ir (KBr): 3600-2500, 1650 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 11.78 (1H, s, NH), 8.04 (1H, s, C_4-H), 7.75 (1H, dd, J= 7.8 and 0.9 Hz, C_5-H), 7.48 (1H, m, C_7-H), 7.34-7.25 (3H, m, C_8-H and 2 Ar-H), 7.22-7.08 (3H, m, C_6-H and 2 Ar-H), 6.05 (1H, d, J= 5.1 Hz, OH), 5.96 (1H, d, J= 5.1 Hz, CH). ^{13}C-Nmr (DMSO-d_6) δ: 161.1 ($C_{2'}$, J_{CF}= 246 Hz), 160.6 (C_2), 138.0 (C_{8a}), 135.2 (C_3), 135.0 (C_4), 130.3 ($C_{1'}$, J_{CF}= 14 Hz), 129.8 (C_7), 129.0 ($C_{4'}$*, J_{CF}= 8 Hz), 128.7 ($C_{6'}$*, J_{CF}= 3.4 Hz), 128.0 (C_5), 124.0 ($C_{5'}$, J_{CF}= 3 Hz), 121.8 (C_6), 119.0 (C_{4a}), 115.2 (C3',J_{CF}= 21 Hz), 114.8 (C_8), 63.0 (C-OH, J_{CF}= 4.1 Hz).

3-(α-Hydroxy-4-chlorobenzyl)-2(1*H*)-quinolinone (**7**). mp 186-188 °C (ethanol). Anal. Calcd for $C_{16}H_{12}NO_2Cl$: C, 67.26; H, 4.23; N, 4.90. Found: C, 66.88; H, 4.46; N, 4.45. Ir (KBr): 3600-2600, 1660 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 11.81 (1H, s, NH), 8.06 (1H, s, C_4-H), 7.73 (1H, d, J= 7.9 Hz, C_5-H), 7.44 (2H, d, J= 8.3 Hz, $C_{3'}$-H, $C_{5'}$-H), 7.43 (1H, overlapped triplet, C_7-H), 7.34 (2H, d, J= 8.3 Hz, $C_{2'}$-H, $C_{6'}$-H), 7.30 (1H, d, J= 8.3 Hz, C_8-H), 7.17 (1H, t, J= 7.9 Hz, C_6-H), 5.98 (1H, d, J= 4.2 Hz, OH), 5.80 (1H, d, J= 4.2 Hz, CH). ^{13}C-Nmr (DMSO-d_6) δ: 160.1 (C_2), 142.9 ($C_{1'}$), 137.7 (C_{8a}), 136.3 (C_3), 134.2 (C_4), 131.3 ($C_{4'}$), 129.7 (C_7), 128.5 ($C_{3'}$ and $C_{5'}$), 127.8 (C_5, $C_{2'}$, and $C_{6'}$), 121.8 (C_6), 119.0 (C_{4a}), 114.7 (C8), 68.2 (C-OH).

3-(α-Hydroxy-2-chlorobenzyl)-2(1*H*)-quinolinone (**8**). mp 172-173 °C (ethanol). Anal. Calcd for

$C_{16}H_{12}NO_2Cl$: C, 67.26; H, 4.23; N, 4.90. Found: C, 66.89; H, 4.49; N, 4.75. Ir (KBr): 3600-2600, 1650 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 11.80 (1H, s, NH), 7.79 (1H, s, C_4-H), 7.68 (1H, d, J= 7.1 Hz, C_5-H), 7.52-7.36 (3H, m, C_7-H and 2 Ar-H), 7.36-7.26 (3H, m, C_8-H and 2 Ar-H), 7.16 (1H, t, J= 7.1 Hz, C_6-H), 6.13 (1H, d, J= 5.3 Hz, OH), 5.93 (1H, d, J= 5.3 Hz, CH). ^{13}C-Nmr (DMSO-d_6) δ: 161.4 (C_2), 141.3 ($C_{1'}$), 138.7 (C_{8a}), 136.0 (C_4), 135.9 ($C_{2'}$), 133.2 (C_3), 130.5 ($C_{3'}$)*, 129.8 ($C_{4'}$)*, 129.4 (C_7)*, 129.0 ($C_{5'}$)*, 128.6 ($C_{6'}$)*, 127.6 (C_5), 122.4 (C_6), 119.5 (C_{4a}), 115.4 (C_8), 66.6 (C-OH).

3-(α-Hydroxy-diphenylmethyl)-2(1*H*)-quinolinone (**9**). mp 299 °C (decomp.) (ethyl acetate). Anal. Calcd for $C_{22}H_{17}NO_2$: C, 80.71; H, 5.23; N, 4.28. Found: C, 80.53; H, 5.41; N, 4.07. Ir (KBr): 3600-2600, 1650 cm^{-1}. ^{1}H-Nmr (DMSO-d_6) δ: 12.24 (1H, s, NH), 7.61-7.51 (2H, m), 7.41-7.16 (13 H, m), 7.09 (1H, s, OH). ^{13}C-Nmr (DMSO-d_6) δ: 163.3 (C_2), 145.6 ($C_{1'}$), 138.3 (C_{8a}), 138.2 (C_4), 136.6 (C_3), 131.4 (C_7), 129.1 (C_5), 128.5 ($C_{3'}$), 127.9 ($C_{2'}$), 127.8 ($C_{4'}$), 123.4 (C_6), 119.1 (C_{4a}), 115.7 (C_8), 81.2 (C-OH).

3-Trimethylsilyl-2(1*H*)-quinolinone (**10**). mp 140 °C (petroleum ether). Anal. Calcd for $C_{12}H_{15}NOSi$: C, 66.31; H, 6.96; N, 6.44. Found: C, 65.95; H, 6.94; N, 6.23. Ir (KBr): 3300-2500, 1650 cm^{-1}. ^{1}H-Nmr ($CDCl_3$) δ: 12.36 (1H, s, NH), 7.90 (1H, s, C_4-H), 7.54 (1H, dd, J= 8.1 and 0.9 Hz, C_5-H), 7.48 (1H, m, C_7-H), 7.36 (1H, d, J=8.1 Hz, C_8-H), 7.17 (1H, m, C_6-H), 0.39 (9H, s, $(CH_3)_3Si$). ^{13}C-Nmr ($CDCl_3$) δ: 167.0 (C_2), 147.1 (C_4), 139.3 (C_{8a}), 133.7 (C_3), 130.3 (C_7), 127.5 (C_5), 122.0 (C_6), 120.0 (C_{4a}), 115.6 (C_8), -1.7 $(CH_3)_3Si$.

2-Quinolyl Benzoate (**12**). mp 95-96 °C (hexane) (lit.,[18] mp 95 °C). Ir (KBr): 1725 cm^{-1}. ^{1}H-Nmr ($CDCl_3$) δ: 8.34-8.26 (3H, m, C_8-H and 2 Ph-H), 8.06 (1H, d, J= 8.6 Hz, C_4-H), 7.89 (1H, d, J= 7.8, C_5-H), 7.76 (1H, m, C_7-H), 7.67 (1H, m, C_6-H), 7.62-7.50 (3H, m), 7.33 (1H, d, J= 8.6 Hz, C_3-H). ^{13}C-Nmr ($CDCl_3$) δ: 164.9 (COO), 158.6 (C_2), 148.6 (C_{8a}), 139.9 (C_4), 133.8 ($C_{4'}$), 130.6 ($C_{1'}$)*, 130.4 ($C_{2'}$, $C_{6'}$), 130.1 (C_7)*, 128.6 (C_8)*, 128.5 ($C_{3'}$, $C_{5'}$), 127.4 (C_5), 126.5 (C_6), 115.7 (C_3).

Ethyl 2-Quinolylcarbonate (**13**). Obtained as an oil. Anal. Calcd for $C_{12}H_{11}NO_3$: C, 66.35; H, 5.10; N, 6.45. Found: C, 65.98; H, 5.31; N, 6.12. Ir (film): 1765 cm^{-1}. ^{1}H-Nmr ($CDCl_3$) δ: 8.23 (1H, d, J= 8.9 Hz, C_4-H), 8.01 (1H, d, J= 8.7 Hz, C_8-H), 7.82 (1H, d, J= 8.1 Hz, C_5-H), 7.71 (1H, m, C_7-H), 7.53 (1H, m, C_6-H), 7.24 (1H, d, J= 8.9 Hz, C_3-H), 4.37 (2H, q, J= 7.1 Hz, O-CH_2), 1.41 (3H, t, J= 7.1 Hz, O-CH_2-CH_3). ^{13}C-Nmr ($CDCl_3$) δ: 156.0 (COO), 152.9 (C_2), 146.4 (C_{8a}), 140.3 (C_4), 130.3 (C_7), 128.7 (C_5), 127.5 (C_6), 127.2 (C_{4a}), 126.7 (C_8), 114.8 (C_3), 65.1 (O-CH_2), 14.2 (O-CH_2-CH_3).

Ethyl 2-Oxo-1*H*-quinoline-3-carboxylate (**14**). mp 160-162 °C (ethanol/ether) (lit.,[19] mp 162-163 °C). ^{1}H-Nmr ($CDCl_3$) δ: 8.58 (1H, s, C_4-H), 8.12 (1H, d, J= 8.1 Hz, C_5-H), 7.97-7.82 (2H, m, C_7-H,

C_8-H), 7.63 (1H, m, C_6-H), 4.18 (2H, q, O-CH_2), 1.22 (3H, t, O-CH_2-CH_3).

2-Oxo-1*H*-quinolinecarboxylic Acid (**15**). mp >300 °C (ethanol) (lit.,[20] mp 330 °C). ^{1}H-Nmr (DMSO-d_6) δ: 11.76 (1H, s, NH), 9.00 (1H, s, C_4-H), 8.06 (1H, dd, J=8.1 and 1.2 Hz, C_5-H), 7.79 (1H, m, C_7-H), 7.53 (1H, d, J= 7.8 Hz, C_8-H), 7.42 (1H, m, C_6-H).

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