Regioselective Synthesis of 3,3-Diethyl-4-(Methylene)-1-Quinol-2-ones by an Intramolecular Microwave Assisted Heck Reaction

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A protocol for the intramolecular Heck cyclization to afford 3,3-diethyl-4-(methylene)-1-quinol-2-ones is described. We observed that the use of microwave irradiation increased the efficiency of the reaction. Several examples are presented which show the versatility of the reaction.

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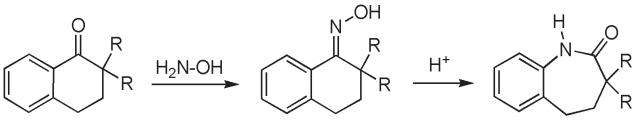
Small molecule heterocycles are a highly sought after class of compounds in the pharmaceutical industry. This trend can be observed by simply reviewing a list of top 200 selling medicines [1]. Often heterocycle-containing molecules can exhibit properties that are desirable for developing safe and effective medicines. In particular, benzazepines and benzazepinones have a rich history in the pharmaceutical community. During the course of a recent research program we became interested in the synthesis of 3,3-disubstituted-1-benzazepin-2-ones.

The wide range of biological activity associated with the benzazepine core has provoked numerous studies of this important pharmacophore. Benzazepinones have been shown to be active as analgesics [2], antitumor agents [3], CNS and gastrointestinal agents [4], antihypertensive agents [5] and cardiovascular agents [6] to name a few.

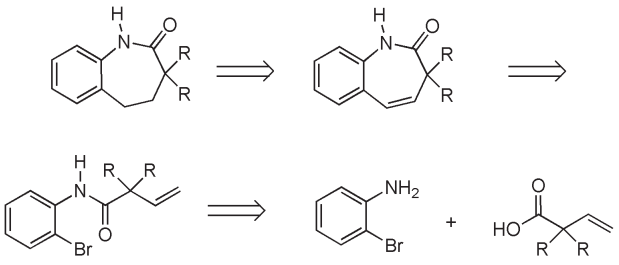
While several synthetic approaches towards 1-benzazepin-2-ones have been developed [7,8], perhaps the most straightforward route is through the Beckmann rearrangement (Scheme 1) [9]. This protocol proceeds from a suitably substituted tetralone by conversion to the oxime and subsequent reaction with a strong acid. The sequence works well for unsubstituted tetralones but is not reliable for the synthesis of highly substituted derivatives. In particular, several problems arise when 3,3-disubstituted-1-benzazepines are the desired products. Such a molecule would require the use of readily available [10] 2,2-disubstituted tetralones as the starting materials. Unfortunately, the required oxime formation is either slowed dramatically or inhibited totally due to steric hindrance about the carbonyl group [11]. In cases where the oxime is formed, the subsequent rearrangement occurs to give a mixture of products, the separation of which is tedious at best [11]. Due to our interest in the synthesis of 3,3-disubstituted-1-benzazepin-2-ones we required a synthesis that was stereoselective, robust and high yielding.

Scheme 1



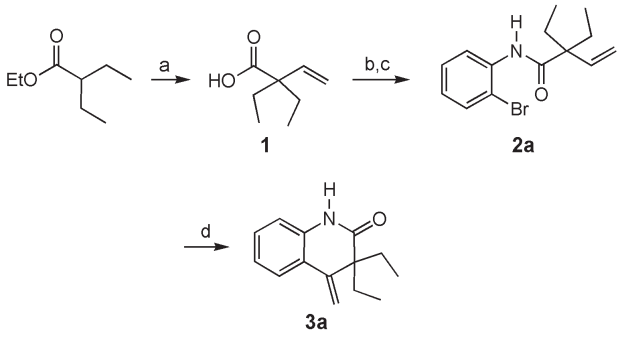
Our attempt to access the desired benzazepinones centered on an intramolecular Heck cyclization. Owing to the commercial availability of 2-bromoanilines we proposed that an intramolecular Heck-type of cyclization could occur as depicted in Scheme 2. One concern with this strategy is the potential to form both six- and seven-membered rings through competing Heck pathways. Indeed a similar phenomenon has been observed in which an intramolecular Heck reaction gave a mixture of 5- and 6-membered ring products [12]. We believe that due to the steric congestion surrounding the quaternary carbon the cyclization would occur to provide the desired benzazepinone.

Scheme 2



The desired Heck precursors were synthesized as depicted in Scheme 3. 2,2-Diethyl-3-butenoic acid [13] was converted to the acid chloride and coupled with 2-bromoaniline. In a test experiment, amide **2a**, when irradiated in a microwave vessel using standard Heck conditions (3 eq. Et_3N, 5 mol % $Pd(OAc)_2$, 10 mol% P(*o*-tolyl)$_3$, DMF) [14], afforded in 15 minutes the unexpected 6-exo-trig derivative [15]. The structure of **3a** was confirmed by NMR analysis. In addition, **3a** was subjected to catalytic hydrogenation, affording a product that exhibited a doublet in the ^1H NMR spectrum corresponding to a secondary methyl group.

Scheme 3[a]



[a](a) see ref. 13, (b) oxalyl chloride, DMF, CH_2Cl_2, (c) 2-bromoaniline, pyridine, CH_2Cl_2, 0 °C to RT, (d) 5 mol % $Pd(OAc)_2$, 10 mol % P(*o*-tolyl)$_3$, 3 Et_3N, DMF, 160 °C, 15 min, microwave.

Considering the mechanistic aspects of the Heck reaction the observed result should not have been unexpected (Scheme 4). After the initial oxidative addition of palladium into the aryl-Br bond the palladium attacks the terminal carbon of the olefin. We believe that the increased non-bonding steric interactions of the tetrasubstituted carbon prevents attack at the internal olefinic carbon. Reductive elimination then provides the product and regenerates the catalyst.

While our initial result was encouraging we believed that the reaction could be optimized to produce shorter reaction times and greater yields. The results of this study are presented in Table 1. In this effort we reduced the reaction time to 5 minutes with the hope to increase the yields. We saw no conversion at 120 °C and a gradual increase of the conversion with an increase in temperature up to 160 °C. At that temperature, complete conversion occurred in 5 minutes to provide **3a** in 63% yield. Upon heating at higher temperatures we observed that **2a** was converted to **3a** but the reaction stopped after approximately 85% conversion. One possibility is that the catalytic cycle in this reaction was terminated because the palladium catalyst precipitated as a black solid out of solution. Hoping to further increase the yields and shorten the reaction time we irradiated **2a** at 160 °C for the times shown in Table 1. At 1 minute

Scheme 4

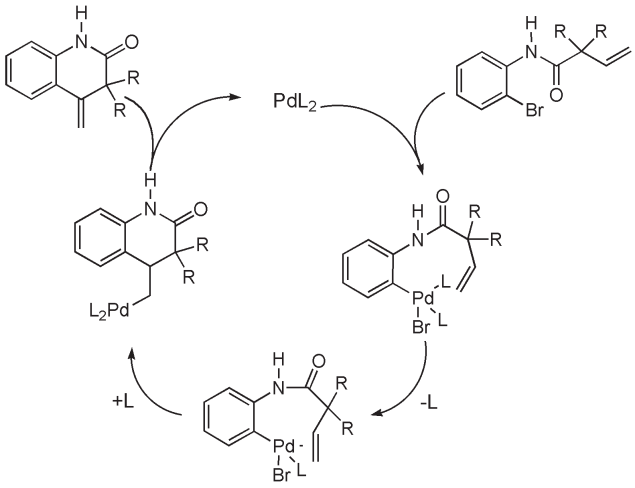
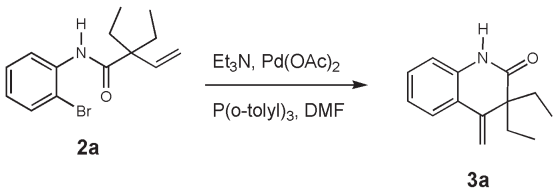


Table 1

Optimization Studies of the Intramolecular Heck reaction



Entry	Temperature (°C)	Time	Conversion (%) [a]	Entry	Temperature (°C)	Time	Conversion (%)[a]
1	120	5 min.	0	8	160	10 min. [b]	63
2	130	5 min.	15	9	160	15 min.	100 (63)
3	140	5 min.	33	10	170	1 min.	84 [c]
4	150	5 min.	64	11	180	1 min.	86 [c]
5	160	1 min.	37	12	160	3 min.	100 (63) [d]
6	160	3 min.	100 (64)	13	160	3 min.	100 (61) [e]
7	160	5 min.	100 (63)	14	160	3 min.	100 (78) [f]

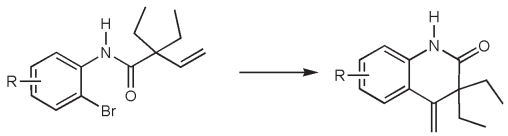
[a] Isolated yields are in parentheses; [b] reaction was run using conventional oil bath heating; [c] Pd precipitated from solution during the reaction; [d] $PdCl_2$ was used as the catalyst; [e] $PdCl_2(PPh_3)_2$ was used as the catalyst; [f] $Pd_2(dba)_3$ was used as the catalyst.

(entry 5) the conversion of **2a** to **3a** was 37%, and optimal conditions appeared to be irradiation for 3 minutes at 160 °C. Indeed, we observed complete conversion at 3 minutes although the yields were not changed to any significant degree. We also ran the reaction in a preheated oil bath to determine if microwave irradiation was providing any beneficial effect. After heating **2a** at 160 °C for 10 minutes we observed only 63% conversion to **3a**, indicating that using microwave irradiation significantly affected the rate of the reaction [16,17]. Various alternative palladium catalysts were investigated to further optimize the process. Although clean reactions were observed and **3a** was the only isolated product, yields were not improved upon switching to $PdCl_2$ or $PdCl_2(PPh_3)_2$ [18] as catalysts (entries 12 and 13). However we were gratified to observe increased yields with $Pd_2(dba)_3$ [19] as the catalyst (entry 14). For all subsequent studies we used $Pd_2(dba)_3$ as the catalyst of choice.

In order to show the generality of the reaction we performed the reaction with several different 2-bromoanilines (Table 2). No problems were encountered with a range of substituents including both electron donating and electron withdrawing groups. The yields for these reactions were all similar to that seen with the unsubstituted example. This observation indicates that the reaction tolerates a variety of substitution on the benzene ring.

Table 2

Generality of the Intramolecular Cyclization



2a-f **3a-f**

R	Yield (%)	R	Yield (%)
H	78	4-F	79
4-OMe	76	4-CF_3	77
4-Me	75	4-OCF_3	75

In conclusion we have developed a rapid, high yielding, regioselective method of generating 4-methylene-3,3-diethyl-1-quinol-2-ones using microwave synthesis and readily available catalysts and solvents. The conditions we described are adaptable to parallel synthesis and could be used to quickly generate a diverse set of analogs. Additional studies aimed at investigating the cyclization with substitution at the terminal olefin are currently underway and will be reported in due course.

EXPERIMENTAL

General.

^{1}H NMR spectra were recorded at 400 MHz and are reported relative to internal TMS standard. ^{13}C NMR spectra were recorded at 100 MHz. All anhydrous solvents and reagents were purchased from commercial sources and were used as received unless otherwise indicated. Elemental analyses were performed by Atlantic Microlab (Norcross, GA). Melting points were determined on a Mel-Temp apparatus and are uncorrected. Silica gel chromatography was performed using an Isco Sg100c automated chromatography instrument and RediSep™ pre-packed silica gel cartridges. All transformations were performed under an inert atmosphere of nitrogen unless otherwise specified. Microwave reactions were performed in a Personal Chemistry Optimizer EXP synthesizer using standard microwave vials.

2,2-Diethylbut-3-enoic acid (**1**) [13].

Ethyl 2-ethylbutyrate (6.0 mL, 36.2 mmole) was added dropwise to a solution of LDA (1 eq.) in THF (36 mL) at -78 °C. The solution was allowed to stir for 30 min. A solution of acetaldehyde (5 mL, 89.1 mmol) in THF (5 mL) was added dropwise and the resulting mixture was allowed to warm to RT and stir for 60 min. Saturated aqueous NH_4Cl (50 mL) and H_2O (50 mL) were added and the two layers were separated. The aqueous layer was extracted with Et_2O (2 x 25 mL) and the organics were dried ($MgSO_4$) and concentrated. The residue was dissolved in pyridine (50 mL) and *p*-tosyl chloride (9.012 g, 47.3 mmol) was added. The mixture was stirred at RT for 2 days. Aqueous HCl (6 *N*, 50 mL) was added and the mixture was extracted with Et_2O (4 x 25 mL). The organics were dried ($MgSO_4$) and concentrated. The residue was dissolved in DBU (50 mL) and heated to 140 °C for 3 hours, then was cooled to RT and poured into 6 *N* aqueous HCl (50 mL). The residue was extracted with Et_2O (3 x 50 mL) and the organics were dried ($MgSO_4$) and concentrated. The residue was purified by silica gel chromatography eluting with hexane to provide ethyl 2,2-diethylbut-3-enoate (3.00 g, 49%) as a colorless oil.

The ester (3.00 g, 17.6 mmol) was dissolved in EtOH (25 mL) in a 75 mL sealed tube. Aqueous NaOH (5 *N*, 10 mL, 50 mmol) was added and the mixture was heated to 150 °C for 3 hours, then was cooled to RT and concentrated. The residue was dissolved in H_2O (50 mL) and extracted with Et_2O (2 x 20 mL). The organic extracts were thrown away and the aqueous layer was treated with 6 *N* aqueous HCl (30 mL). The mixture was extracted with Et_2O (3 x 15 mL). The organics were dried (Na_2SO_4) and concentrated to provide **1** as a pale yellow liquid (2.00 g, 82%). ^{1}H NMR ($CDCl_3$): δ 5.97 (dd, J= 17.8, 11.0 Hz, 1H), 5.24 (d, J= 11.0 Hz, 1H), 5.13 (d, J= 17.8 Hz, 1H), 3.73 (q, J= 7.1 Hz, 2H), 1.75 (q, J= 7.3 Hz, 4H), 0.94 (t, J= 7.3 Hz, 3H), 0.85 (t, J= 7.3 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 182.8, 139.2, 115.3, 53.2, 28.3, 8.8.

N-(2-Bromophenyl)-2,2-diethylbut-3-enamide (**2a**).

2,2-Diethylbut-3-enoic acid (0.999 g, 7.03 mmol) was dissolved in CH_2Cl_2 (15 mL). DMF (3 drops) and oxalyl chloride (1.25 mL, 14.3 mmol) were added and the solution was heated to reflux for 60 min. The solution was cooled to RT and concentrated. The residue was redissolved in CH_2Cl_2 (5 mL) and added dropwise to a cold (0 °C) solution of 2-bromoaniline (1.333 g, 7.75 mmol) and pyridine (0.940 mL, 11.6 mmol) in CH_2Cl_2 (15

mL). The resulting mixture was allowed to warm to RT and stir for 90 min. Water (40 mL) and 1 *N* aqueous HCl (40 mL) were added and the two layers were separated. The aqueous layer was extracted with CH_2Cl_2 (2 x 25 mL). The organics were dried ($MgSO_4$) and concentrated. The crude residue was purified by silica gel chromatography using a 40 g cartridge and eluting with a 10% to 20% ethyl acetate/hexane gradient over 15 min. to provide **2** as a yellow oil (1.640 g, 79%). ^{1}H NMR ($CDCl_3$): δ 8.39 (dd, J= 8.2, 1.6 Hz, 1H), 8.12 (br s, 1H), 7.50 (dd, J= 6.6, 1.6 Hz, 1H), 6.94 (dt, J= 7.4, 1.6 Hz, 1H), 6.06 (dd, J= 17.8, 11.0 Hz, 1H), 5.50 (d, J= 11.0 Hz, 1H), 5.41 (d, J= 17.8 Hz, 1H), 1.82 (m, 4H), 0.90 (t, J= 7.5 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 173.4, 140.5, 136.1, 132.4, 128.5, 125.1, 121.7, 117.8, 113.8, 54.4, 27.5, 8.8.

Anal. Calcd. for $C_{14}H_{18}BrNO$: C: 56.8%, H: 6.1%, N: 4.7%. Found: C: 56.77%, H: 6.12%, N: 4.79%.

N-(2-Bromo-4-methoxyphenyl)-2,2-diethylbut-3-enamide (**2b**).

From 2-bromo-4-methoxyaniline [20] (0.327 g, 1.62 mmole) using the procedure described above the title compound was isolated as a colorless oil (0.335 g, 71%). ^{1}H NMR ($CDCl_3$): δ 8.20 (d, J= 9.0 Hz, 1H), 7.89 (br s, 1H), 7.07 (d, J= 2.9 Hz, 1H), 6.86 (dd, J= 9.0, 2.8 Hz, 1H), 6.06 (dd, J= 17.7, 11.0 Hz, 1H), 5.49 (d, J= 11.0 Hz, 1H), 5.39 (d, J= 17.7 Hz, 1H), 3.77 (s, 3H), 1.81 (m, 4H), 0.90 (t, J= 7.5 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 173.1, 156.5, 140.6, 129.5, 123.1, 117.7, 117.6, 114.8, 114.0, 55.9, 54.2, 27.6, 8.8.

Anal. Calcd. for $C_{15}H_{20}BrNO_2$: C: 55.2%, H: 6.2%, N: 4.3%. Found: C: 55.33%, H: 6.25%, N: 4.38%.

N-(2-Bromo-4-methylphenyl)-2,2-diethylbut-3-enamide (**2c**).

From 2-bromo-4-methylaniline (0.2037 g, 1.43 mmole) using the procedure described above the title compound was isolated (0.3318 g, 75%) as a colorless oil. ^{1}H NMR ($CDCl_3$): δ 8.22 (d, J= 8.4 Hz, 1H), 8.03 (s, 1H), 7.33 (d, J= 1.2 Hz, 1H), 7.10 (dd, J= 8.4, 1.2 Hz, 1H), 6.05 (dd, J= 17.7, 11.0 Hz, 1H), 5.48 (d, J= 11.0 Hz, 1H), 5.44 (d, J= 17.7 Hz, 1H), 2.29 (s, 3H), 1.87-1.76 (m, 4H), 0.89 (t, J= 7.6 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 173.2, 140.5, 135.1, 133.6, 132.6, 129.1, 121.6, 117.7, 113.7, 54.3, 27.5, 20.7, 8.8.

Anal. Calcd. for $C_{15}H_{20}BrNO$: C: 58.1%, H: 6.5%, N: 4.5%. Found: C: 58.39%, H: 6.53%, N: 4.65%.

N-[2-Bromo-4-(trifluoromethyl)phenyl]-2,2-diethyl-3-butenamide (**2d**).

From 2-bromo-4-(trifluoromethyl)aniline (0.332 g, 1.38 mmole) using the procedure described above the title compound was isolated (0.207 g, 41%) as a colorless oil. ^{1}H NMR ($CDCl_3$): δ 8.77 (d, J = 1.8 Hz, 1H), 8.25 (br s, 1H), 7.62 (d, J = 8.4 Hz, 1H), 7.19 (dd, J = 8.4, 1.8 Hz, 1H), 6.05 (dd, J = 17.8, 11.0 Hz, 1H), 5.52 (d, J = 11.0 Hz, 1H), 5.43 (d, J = 17.8 Hz, 1H), 1.83 (m, 4H), 0.89 (t, J = 7.5 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 173.74, 140.29, 136.73, 132.86, 131.10 (q, J = 32.8 Hz), 123.78 (q, J = 272.9 Hz), 121.37 (q, J = 3.6 Hz), 118.21 (q, J = 4.1 Hz), 118.19, 116.93 (q, J = 1.7 Hz), 54.55, 27.34, 8.69.

Anal. Calcd. for $C_{15}H_{17}BrF_3NO$: C: 49.5%, H: 4.7%, N: 3.8%. Found: C: 49.76%, H: 4.80%, N: 3.88%.

N-{2-Bromo-4-[(trifluoromethyl)oxy]phenyl}-2,2-diethyl-3-butenamide (**2e**).

From 2-bromo-4-(trifluoromethoxy)aniline (0.190 mL, 1.26 mmole) using the procedure described above the title compound was isolated (0.225 g, 47%) as a colorless oil. ^{1}H NMR ($CDCl_3$): δ 8.44 (d, J = 9.0 Hz, 1H), 8.11 (s, b, 1H), 7.40 (d, J = 2.4 Hz, 1H), 7.18 (m, 1H), 6.05 (dd, J = 17.8, 11.0 Hz, 1H), 5.51 (d, J = 11.0 Hz, 1H), 5.41 (d, J = 17.8 Hz, 1H), 1.82 (m, 4H), 0.88 (t, J = 7.4 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 173.48, 144.69 (q, J = 1.6 Hz), 140.34, 135.14, 125.27, 122.00, 121.34, 120.59 (q, J = 257.9 Hz), 118.02, 113.46, 54.44, 27.38, 8.66.

Anal. Calcd. for $C_{15}H_{17}BrF_3NO_2$: C: 47.4%; H: 4.5%; N: 3.7%. Found: C: 47.70%; H: 4.55%; N: 3.70%.

N-(2-Bromo-4-fluorophenyl)-2,2-diethyl-3-butenamide (**2f**).

From 2-bromo-4-fluoroaniline (0.150 mL, 1.32 mmole) using the procedure described above the title compound was isolated (0.291 g, 71%) as a colorless oil. ^{1}H NMR ($CDCl_3$): δ 8.32 (dd, J = 9.2, 5.7 Hz, 1H), 7.99 (s, b 1H), 7.27 (m, 1H), 7.03 (m, 1H), 6.05 (dd, J = 17.8, 11.0 Hz, 1H), 5.49 (d, J = 11.0 Hz, 1H), 5.40 (d, J = 17.8 Hz, 1H), 1.81 (m, 4H), 0.88 (t, J = 7.5 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 173.33, 158.47 (d, J = 247.2 Hz), 140.43, 132.60 (d, J = 3.3 Hz), 122.76 (d, J = 7.6 Hz), 119.43 (d, J = 25.2 Hz), 117.88, 115.31 (d, J = 21.4 Hz), 113.82 (d, J = 9.9 Hz), 54.33, 27.45, 8.72.

Anal. Calcd. for $C_{14}H_{17}BrFNO$: C: 53.5%, H: 5.4%, N: 4.5%. Found: C: 53.76%, H: 5.45%, N: 4.58%.

3,3-Diethyl-4-methylene-3,4-dihydroquinolin-2(1*H*)-one (**3a**).

A 2.5 mL microwave vial was charged with *N*-(2-bromophenyl)-2,2-diethylbut-3-enamide (0.1045 g, 0.353 mmol). DMF (2 mL) was added followed by Et_3N (0.140 mL, 1.00 mmol), tri-*o*-tolylphosphine (0.0104 g, 0.0342 mmol) and $Pd_2(dba)_3$ (0.0076 g, 0.0083 mmol). The mixture was heated to 160 °C in a microwave reactor for 3 min, then was cooled to RT and poured into H_2O (25 mL). The mixture was extracted with Et_2O (4 x 10 mL). The organics were dried ($MgSO_4$) and concentrated. The crude residue was purified by silica gel chromatography on a 12 g cartridge, eluting with 15% EtOAc/hexane to provide **2** as a white solid (0.0593 g, 78%), mp= 73-74 °C. ^{1}H NMR ($CDCl_3$): δ 8.84 (br s, 1H), 7.57 (dd, J= 6.6, 1.3 Hz, 1H), 7.20 (dt, J= 6.6, 1.3 Hz, 1H), 7.01 (dt, J= 6.6, 1.3 Hz, 1H), 6.76 (dd, J= 6.6, 1.3 Hz, 1H), 5.83 (s, 1H), 5.14 (s, 1H), 2.00 (m, 2H), 1.72 (m, 2H), 0.87 (t, J= 7.3 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 175.0, 142.1, 135.0, 129.4, 125.0, 123.4, 122.8, 115.5, 112.2, 53.8, 31.4 and 9.1.

Anal. Calcd. for $C_{14}H_{17}NO$: C: 78.1%, H: 8.0%, N: 6.5%. Found: C: 77.88%, H: 7.87%, N: 6.30%.

3,3-Diethyl-6-methoxy-4-methylene-3,4-dihydroquinolin-2(1*H*)-one (**3b**).

From *N*-(2-bromo-4-methoxyphenyl)-2,2-diethylbut-3-enamide (0.1496 g, 0.459 mmole) using the procedure described above the title compound was isolated as a white solid (0.0860 g, 76%), mp= 136.5-138 °C. ^{1}H NMR ($CDCl_3$): δ 7.96 (br s, 1H), 7.10 (d, J= 1.6 Hz, 1H), 6.78 (dd, J= 8.6, 2.5 Hz, 1H), 6.63 (d, J= 8.6 Hz, 1H), 5.81 (s, 1H), 5.16 (s, 1H), 3.81 (s, 3H), 1.98 (m, 2H), 1.71 (m, 2H), 0.86 (t, J= 7.3 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 174.3, 155.9, 142.4, 128.8, 123.8, 116.3, 115.3, 112.5, 110.0, 55.9, 53.6, 31.5 and 9.1.

Anal. Calcd. for $C_{15}H_{19}NO_2$: C: 73.4%, H: 7.8%, N: 5.7%. Found: C: 73.23%, H: 7.82%, N: 5.65%.

3,3-Diethyl-6-methyl-4-methylene-3,4-dihydroquinolin-2(1*H*)-one (**3c**).

From *N*-(2-bromo-4-methylphenyl)-2,2-diethylbut-3-enamide (0.1064 g, 0.343 mmole) using the procedure described above the

title compound was isolated as a white solid (0.0620 g, 79%), mp= 122-123 °C. ^{1}H NMR ($CDCl_3$): δ 7.86 (s, 1H), 7.38 (s, 1H), 7.01 (d, J= 8.0 Hz, 1H), 6.58 (d, J= 8.0 Hz, 1H), 5.82 (s, 1H), 5.13 (s, 1H), 2.32 (s, 3H), 2.05-1.94 (m, 2H), 1.73-1.67 (m, 2H), 0.86 (t, J=7.5 Hz, 6H).

Anal. Calcd. for $C_{15}H_{19}NO$: C: 78.6%, H: 8.4%, N: 6.1%. Found: C: 78.53%, H: 8.60%, N: 5.94%.

3,3-Diethyl-4-methylidene-6-(trifluoromethyl)-3,4-dihydro-2(1*H*)-quinolinone (**3d**).

From (0.111 g, 0.305 mmole) using the described procedure the title compound was isolated (0.066 g, 77%) as a pale yellow solid, m.p.= 75-78 °C. ^{1}H NMR ($CDCl_3$): δ 8.04 (s, b, 1H), 7.66 (d, J = 8.2 Hz, 1H), 7.24 (m, 1H), 6.92 (s, 1H), 5.91 (s, 1H), 5.27 (s, 1H), 1.98 (dq, J = 13.9, 7.3 Hz, 2H), 1.71 (dq, J = 13.7, 7.3 Hz, 2H), 0.85 (t, J = 7.3 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 174.97, 141.14, 135.33, 131.00 (q, J = 32.8 Hz), 126.06, 125.60, 123.90 (q, J = 272.0), 120.02 (q, J = 3.8 Hz), 114.75, 112.40 (q, J = 3.9 Hz), 53.74, 31.26, 8.97.

Anal. Calcd. for $C_{15}H_{16}F_3NO$: C: 63.60%, H: 5.69%, N: 4.94%. Found: C: 63.78%, H: 5.88%, N: 4.71%.

3,3-Diethyl-4-methylidene-6-[(trifluoromethyl)oxy]-3,4-dihydro-2(1*H*)-quinolinone (**3e**).

From (0.108 g, 0.284 mmole) using the described procedure the title compound was isolated (0.064 g, 75%) as a white solid, m.p. = 123-124 °C. ^{1}H NMR ($CDCl_3$): δ 8.66 (s, b, 1H), 7.40 (d, J = 1.8 Hz, 1H), 7.06 (dd, J = 8.6, 1.6 Hz, 1H), 6.74 (d, J = 8.6 Hz, 1H), 5.82 (s, 1H), 5.21 (s, 1H), 1.99 (m, 2H), 1.71 (dq, J = 13.7, 7.3 Hz, 2H), 0.85 (t, J = 7.3 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 175.19, 145.00 (q, J = 2.0 Hz), 141.23, 133.75, 124.02, 122.21, 120.74 (q, J = 256.7 Hz), 117.82, 116.61, 113.73, 53.45, 31.43, 9.01.

Anal. Calcd. for $C_{15}H_{16}F_3NO_2$: C: 60.20%, H: 5.39%, N: 4.68%. Found: C: 60.17%, H: 5.56%, N: 4.49%.

3,3-Diethyl-6-fluoro-4-methylidene-3,4-dihydro-2(1*H*)-quinolinone (**3f**).

From (0.099 g, 0.315 mmole) using the described procedure the title compound was isolated (0.058 g, 79%) as a white solid, m.p.= 122-123 °C. ^{1}H NMR ($CDCl_3$): δ 8.25 (s, b, 1H), 7.26 (dd, J = 9.5, 2.7 Hz, 1H), 6.91 (m, 1H), 6.66 (dd, J = 8.8, 4.8 Hz, 1H), 5.80 (s, 1H), 5.19 (s, 1H), 1.98 (dq, J = 13.8, 7.3 Hz, 2H), 1.69 (dq, J = 13.7, 7.3 Hz, 2H), 0.85 (t, J = 7.3 Hz, 6H). ^{13}C NMR ($CDCl_3$): δ 174.75, 159.18 (d, J = 240.9 Hz), 141.59 (d, J = 2.1 Hz), 131.23 (d, J = 2.3 Hz), 124.22 (d, J = 7.4 Hz), 116.65 (d, J = 8.2 Hz), 116.21 (d, J = 23.5 Hz), 113.38, 111.35 (d, J = 23.6 Hz), 53.40, 31.53, 9.03.

Anal. Calcd. for $C_{14}H_{16}FNO$: C: 72.08%, H: 6.91%, N: 6.00%. Found: C: 71.73%, H: 7.12%, N: 5.65%.

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