Synthesis and Cycloaddition Reactions of Ethyl Glyoxylate Imines. Synthesis of Substituted Furo-[3,2-c]quinolines and 7H-Indeno[2,1-c]quinolines

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Lewis acid catalyzed cycloaddition reactions of ethyl glyoxylate imines to dihydrofuran and indene yield substituted hexahydrofuro[3,2-c]- and tetrahydro-7H-indeno[2,1-c]quinolines respectively. Oxidation of the adducts with 2,3-dichloro-5,6-dicyanobenzoquinone affords the corresponding aromatic compounds.

The synthesis of nitrogen heterocycles through cycloaddition reaction of imines has stimulated much preparative and mechanistic work [3]. The reaction of Schiff bases with electron-rich olefins has been utilized for the synthesis of quinoline derivatives [4]. From a mechanistic point of view these are considered Diels-Alder reactions with inverse electron demand (LUMO$_{diene}$-controlled) [5]. The lowering of the imine LUMO with an electron-withdrawing group will enhance the reactivity and broaden the spectrum of potential dienophiles [6]. In this context we have been concerned with the synthesis and cycloaddition reactivity of substituted 1-phenyl-2-aryliminoethanones (phenylglyoxal anils) [7]. These compounds afford substituted pyridines, cyclopenta[c]quinolines and phenanthridines by Lewis acid catalyzed reaction with 1,3-butadienes, cyclopentadiene and 1,3-cyclohexadiene [7c].

In this paper we describe the synthesis of a related class of imines, ethyl aryliminoacetates (ethyl glyoxylate anils) and their utilization for the production of interesting heterocycles such as furo[3,2-c]quinoline and indeno[2,1-c]quinoline derivatives.

Results and Discussion.

The reaction of ethyl glyoxylate (or its hydrate) 1 with anilines 2a-c bearing electron-donating groups gives easily and quantitatively (25°, toluene or dichloromethane, 0.5 hour) the corresponding ethyl glyoxylate anils 3.
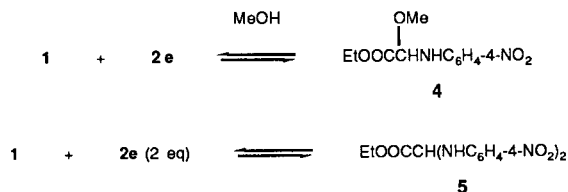
EtO$_2$CCHO + H$_2$N—⟨ring⟩—X $\underset{+H_2O}{\overset{-H_2O}{\rightleftharpoons}}$ EtO$_2$C—CH=N—⟨ring⟩—X

1   2   3
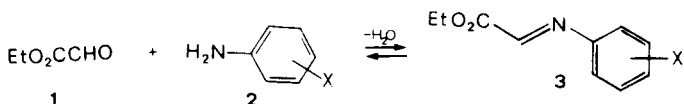
a, X = H; b, X = 4-CH$_3$; c, X = 4-OCH$_3$;
d, X = 4-Cl; e, X = 4-NO$_2$; f, X = 2-NO$_2$

On the contrary, anilines 2d-f with an electron-withdrawing group react sluggishly (110°, toluene, 0.5 hour)

yielding complex reaction mixtures (from nmr monitoring). Similar problems were encountered in the synthesis of phenylglyoxal anils [7a]. Since most anils are difficult to isolate and are highly hygroscopic, we suggested the use of their adducts with methanol, directly obtained in the solid state when the condensation reaction is run in methanol [7a].

In the present case, reaction of 4-nitroaniline 2e with ethyl glyoxylate in methanol gives indeed a crude consisting exclusively of 4. On the other hand, when the same reaction is carried out in toluene in the presence of two equivalents of amine, the adduct 5 precipitates from the solution.

$$1 \; + \; 2e \; \underset{MeOH}{\rightleftharpoons} \; \overset{\overset{OMe}{|}}{EtOOCCHNHC_6H_4\text{-}4\text{-}NO_2}$$

4

$$1 \; + \; 2e \; (2\ eq) \; \rightleftharpoons \; EtOOCCH(NHC_6H_4\text{-}4\text{-}NO_2)_2$$

5

We may conclude that the complex mixtures obtained in toluene from the reaction of equimolar ethyl glyoxylate and 2d-f in toluene consist of free anil 3 and of products derived from the addition of water or unreacted aniline across the C–N double bond. In the case of phenylglyoxal anils we demonstrated that the free imine and the adducts with aniline, water or methanol, equilibrate in solution [7a]. Ethyl glyoxylates behave similarly. Thus, the crude product mixture can be directly used for synthetic purposes without further purification (which would eventually lead to extensive decomposition).

Vicinal substituted Schiff bases show preference for *E* configuration [8]. We have confirmed this stereochemistry around the C–N double bond in the anil 3c by means of a nuclear Overhauser effect (nOe) investigation [9]. The saturation of the easily recognized aniline *ortho* protons at

δ 7.34 brings about a 18.9% enhancement of the azomethine proton singlet at δ 7.91. In the reciprocal experiment the *ortho* aniline protons are 6.1% enhanced. These findings will unambigously assign the E configuration to **3c**. The small (0.9%) enhancement of the azomethine proton when the methylene group is irradiated is not sufficient for a definitive determination of the preferred reciprocal conformation (*s-cis* or *s-trans*) of the C=N and C=O groups.

The free anils or the product mixtures obtained from the reaction of ethyl glyoxylate with anilines **2a-f** were reacted with dihydrofuran (1.2 equivalents) in dichloromethane at room temperature with catalytic amounts of boron trifluoride etherate. The reactions are instantaneous and afford the hexahydrofuro[3,2-c]quinoline stereoisomers **6** and **7**, which could in most cases be separated by flash chromatography and characterized through care-

ful analysis of nuclear Overhauser effects and other magnetic parameters.
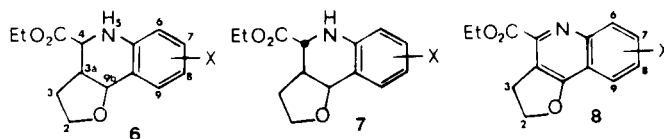
The most diagnostic parameter for structural assignment is the scalar coupling constant between protons H-3a and H-4. In the adduct **7d**, the constant J (3a,4) = 9.2 Hz is relevant and indicative of *anti* reciprocal orientation of protons H-3a and H-4. This orientation is only possible when the furanoic ring and the carbethoxy group are on opposite sides of the cyclohexene ring of **7d**, with equatorial position of the carbethoxy group. The nOe analysis confirms this structural assignment: a strong reciprocal di-

Table I

Yields, Analytical Data and Selected NMR Frequencies for the 4-Carboxyethyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinolines **6a-f**

Compound (X)	Yield %	mp °C (Solvent)	Formula	Analysis [a] C%	H%	N%	NMR H_2	H_3	H_{3a}	H_4	H_{9b}
6a (H)	31	49-50 (ethanol)	$C_{14}H_{17}NO_3$	67.96 (68.02)	6.73 (6.88)	5.67 (5.67)	3.79	1.97	3.12	4.21	5.22
6b (8-CH$_3$)	27	82-83 (methanol)	$C_{15}H_{19}NO_3$	68.30 (68.96)	7.38 (7.28)	5.32 (5.36)	3.76	1.96	3.10	4.15	5.18
6c (8-OCH$_3$)	33	96-97 (ethanol)	$C_{15}H_{19}NO_4$	64.94 (64.98)	7.00 (6.86)	4.97 (5.05)	3.80	1.98	3.10	4.14	5.18
6d (8-Cl)	38	123-124 (ethanol)	$C_{14}H_{16}ClNO_3$	60.25 (59.68)	5.85 (5.68)	4.92 [b] (4.97)	3.80	1.92	3.09	4.19	5.15
6e (8-NO$_2$)	36	175-176 (ethanol)	$C_{14}H_{16}N_2O_5$	57.23 (57.53)	5.53 (5.48)	9.53 (9.59)	3.82	1.89	3.12	4.37	5.20
6f (6-NO$_2$)	41	110-111 (ethanol)	$C_{14}H_{16}N_2O_5$	57.48 (57.53)	5.62 (5.48)	9.55 (9.59)	3.81	1.96	3.13	4.42	5.21

[a] Calculated values in parenthesis. [b] Cl, 12.54 (12.61).

Table II

Yields, Analytical Data and Selected NMR Frequencies for the 4-Carboxyethyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinolines **7a-e**

Compound (X)	Yield %	mp °C (Solvent)	Formula	Analysis [a] C%	H%	N%	NMR H_2	H_3	H_{3a}	H_4	H_{9b}
7a (H)	23	61-62 (cyclohexane)	$C_{14}H_{17}NO_3$	67.98 (68.02)	6.97 (6.88)	5.55 (5.67)	3.91	2.26	2.62	3.62	4.63
7b (8-CH$_3$)	26	oil	$C_{15}H_{19}NO_3$	68.42 (68.96)	7.20 (7.28)	5.31 (5.36)	3.90	2.22	2.60	3.57	4.60
7c (8-OCH$_3$)	15	oil	$C_{15}H_{19}NO_4$	64.90 (64.98)	6.92 (6.86)	4.67 (5.05)	3.76	2.27	2.67	3.57	4.64
7d (8-Cl)	31	75-76 (cyclohexane)	$C_{14}H_{16}ClNO_3$	59.40 (59.68)	5.78 (5.68)	4.88 [b] (4.97)	3.91	2.26	2.63	3.62	4.60
7e (8-NO$_2$)	21	99-100 (water)	$C_{14}H_{16}N_2O_5$	57.26 (57.53)	5.56 (5.48)	9.73 (9.59)	3.96	2.32	2.57	3.75	4.63

[a] Calculated values in parenthesis. [b] Cl, 12.27 (12.61).

polar interaction is found between protons H-3a and H-9b (with 14.7% enhancement of H-3a from saturation of H-9b and 15.8% in the reverse experiment), a smaller one between protons H-3a and H-4 (with 3.2% and 7.2% enhancement respectively) but none between protons H-4 and H-9b.

In the adduct **6d** the constant J (3a,4) = 3.4 Hz is significantly smaller and typical for *gauche* orientation. This orientation is present in both conformers of the configuration having *cis* orientation of the furanoic ring and the carbethoxy group. As expected for this configuration, reciprocal nOe interactions were measured for protons H-3a, H-4 and H-9b (enhancements: 8.0% of H-3a and 2.2% of H-9b from saturation of H-4; 1.4% of H-4 and 14.7% of

H-3a from saturation of H-9b; 9.2% of H-4 and 18.7% of H-9b from saturation of H-3a).

The combined yields of **6** and **7** are in the 60-70% range. The two isomers are obtained in the approximate 3:2 ratio, but for the case of **6f** and **7f** where the 9:1 ratio was observed. These two latter isomers, with the same R_f in all eluting solvents, could not be separated by chromatography; only the major isomer **6f** could be purified by crystallization.

Yields, spectroscopic and analytical data for compounds **6a-f** and **7a-e** are reported in Table I and Table II respectively.

The adducts **6a-f** were oxidized to 2,3-dihydrofuro-[3,2-*c*]quinolines **8a-f** with 2,3-dichloro-5,6-dicyanobenzo-

Table III

Yields, Analytical Data and Selected NMR Frequencies for the 4-Carboxyethyl-2,3-dihydrofuro[3,2-*c*]quinolines **8a-f**

Compound (X)	Yield %	mp °C (Solvent)	Formula	Analysis [a] C%	H%	N%	NMR H_2	H_3	H_6	H_7	H_8	H_{9b}
8a (H)	74	128-129 (ethanol)	$C_{14}H_{13}NO_3$	68.97 (69.14)	5.37 (5.35)	5.68 (5.76)	4.93	3.76	8.22	7.75	7.56	7.96
8b (8-CH₃)	66	128-129 (ethanol)	$C_{15}H_{15}NO_3$	69.77 (70.04)	5.79 (5.84)	5.30 (5.45)	4.91	3.75	8.12	7.54	--	7.72
8c (8-OCH₃)	69	136-137 (ethanol)	$C_{15}H_{15}NO_4$	65.42 (65.93)	5.41 (5.49)	4.98 (5.13)	4.91	3.76	8.12	7.35	--	7.14
8d (8-Cl)	68	141-142 (methanol)	$C_{14}H_{12}ClNO_3$	70.15 (70.48)	4.29 (4.33)	4.12 [b] (4.33)	4.93	3.76	8.15	7.63	--	7.94
8e (8-NO₂)	73	197-198 (ethanol)	$C_{14}H_{12}N_2O_5$	58.21 (58.33)	4.08 (4.17)	9.65 (9.72)	5.03	3.82	8.33	8.45	--	8.94
8f (6-NO₂)	66	188-189 (toluene)	$C_{14}H_{12}N_2O_5$	57.83 (58.03)	3.93 (4.07)	9.88 (9.72)	4.99	3.78	--	8.19	7.60	8.03

[a] Calculated values in parenthesis. [b] Cl, 11.03 (10.97).

Table IV

Yields, Analytical Data and Selected NMR Frequencies for the 6-Carboxyethyl-5,6,6a,11b-tetrahydro-7*H*-indeno[2,1-*c*]quinolines **9a-f**

Compound (X)	Yield %	mp °C (Solvent)	Formula	Analysis [a] C%	H%	N%	NMR H_6	H_{6a}	H_7	$H_{7'}$	H_{11b}
9a (H)	28	115-116 (ethanol)	$C_{19}H_{19}NO_2$	77.60 (77.82)	6.54 (6.48)	4.63 (4.78)	4.23	3.50	3.17	2.78	4.52
9b (2-CH₃)	72	163-164 (ethanol)	$C_{20}H_{21}NO_2$	78.00 (78.18)	6.58 (6.84)	4.53 (4.56)	4.19	3.47	3.18	2.77	4.47
9c (2-OCH₃)	73	150-151 (ethanol)	$C_{20}H_{21}NO_3$	74.19 (74.30)	6.52 (6.50)	4.24 (4.33)	4.17	3.48	3.18	2.78	4.49
9d (2-Cl)	65	170-171 (ethanol)	$C_{19}H_{18}ClNO_2$	69.42 (69.15)	5.50 (5.53)	4.27 [b] (4.08)	4.21	3.49	3.12	2.77	4.45
9e (2-NO₂)	62	176-177 (ethanol)	$C_{19}H_{18}N_2O_4$	67.21 (67.46)	5.46 (5.33)	8.29 (8.28)	4.36	3.52	3.02	2.79	4.50
9f (4-NO₂)	72	114-115 (toluene-hexane)	$C_{19}H_{18}N_2O_4$	67.29 (67.46)	5.41 (5.33)	8.37 (8.28)	4.40	3.51	3.09	2.86	4.53

[a] Calculated values in parenthesis. [b] Cl, 10.84 (10.87).

quinone (DDQ) in toluene at room temperature. Yields (crystallized products), spectroscopic and analytical data are reported in Table III.

At variance with the reaction with dihydrofuran, the reaction with indene is totally selective, affording only one product, the tetrahydro-7H-indeno[3,2-c]quinoline derivative **9**. The structure of the product was established by nmr analysis. In the case of **9d**, the aromatic resonances at δ 6.53, 6.91 and 7.24 constitute a typical AMX system of
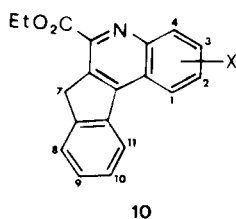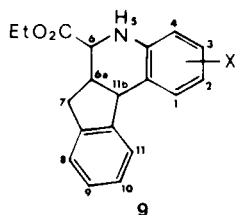
an asymmetric trisubstituted phenyl ring. The irradiation of the signal at δ 7.24 (H-1) induces a 15.8% enhancement of the H-11 resonance at δ 7.48 (the reciprocal experiment gives 14.5% of the H-1 resonance). Therefore the adduct is the 7-H regioisomer. The saturation of H-1 also perturbes a doublet at δ 4.45 (6.5% enhancement) to be attributed to H-11b. This signal is part of a scalar coupling system which encompasses also the multiplets of H-6, H-6a and of methylenic H-7 protons. The saturation of the relatively isolated multiplet of H-6a at δ 3.49 induces 13.0% and 18.5% nOe enhancements of the doublets of H-6 and H-11b at δ at 4.21 and 4.45 respectively (with 9.6 and 12.3% enhancements of H-6a when H-6 and H-11b are irradiated). The spectral proximity of these latter resonances prevents the measurement of their reciprocal dipolar interactions. However the magnitudes of the reported interactions and of the scalar coupling between H-6 and H-6a, J (6,6a) = 3.5 Hz, indicate that the five-membered ring is *cis* oriented with respect to the carbethoxy group.

Yields (crystallized products), spectroscopic and analytical data for compounds **9a-f** are reported in Table IV.

The adducts **9** were subjected to oxidative aromatization with DDQ to the homologues **10**. The oxidation occurs very easily when the substituent X is not a strong electron-withdrawing group, with isolation of 7H-indeno-[2,1-c]quinolines **10a-d**. With **9e,f** only complex mixtures were obtained, which were not further investigated. No other oxidative agents were tested. Yields (crystallized products), spectroscopic and analytical data for compounds **10a-d** are reported in Table V.

EXPERIMENTAL

Nuclear Overhauser Effect Determination [9].

The tubes were freed from oxygen by sonication under nitrogen flow. The usual routine for gated decoupling was adopted. As only modification, every multiplet was saturated with the least power by an 8 seconds cyclic perturbation of all lines of the multiplet [10]. The percentage enhancements were obtained from the multiplier which brings the reference multiplet to exact matching with the perturbated multiplet. Errors were estimated at about 0.3%.

Synthesis of Ethyl-X-phenyliminoacetates **3a-f**.

General Procedure.

A solution containing 1.2 g of ethyl glyoxylate hydrate (10 mmoles), substituted aniline (10 mmoles) and anhydrous sodium sulfate (1 g) in 20 ml of toluene was stirred for 0.5 hour at room temperature for **3a-c** or for 0.5 hour at 110° for **3d-f**. The solution was then filtered and the solvent removed under reduced pressure. Attempted purification by chromatography or distillation led to extensive decomposition of compounds **3**. The oily residues were characterized by nmr and ms. Compound **3a** had nmr: δ 1.42 (t, CH$_3$, J = 7.0), 4.44 (q, CH$_2$), 7.25-7.50 (m, aromatics), 7.93 (s, azomethine-H); ms: m/e 177 (M$^+$, 16%), 104 (100%), 77, 51. Compound **3b** had nmr: δ 1.41 (t, CH$_2$-CH_3, = 7.0), 2.38 (s, CH$_3$), 4.43 (q, CH$_2$), 7.23 (s, 4H, aromatics), 7.93 (s, azomethine-H); ms: m/e 191 (M$^+$, 21%), 118 (100%), 91, 65. Compound **3c** had nmr: δ 1.37 (t, CH$_2$-CH_3, J = 7.0), 3.81

Table V

Yields, Analytical Data and Selected NMR Frequencies for the 6-Carboxyethyl-7H-indeno[2,1-c]quinolines **10a-d**

Compound (X)	Yield %	mp °C (Solvent)	Formula	Analysis [a] C%	H%	N%	NMR H$_1$	H$_3$	H$_4$	H$_7$	H$_{11}$
10a (H)	67	204-205 (ethanol)	C$_{19}$H$_{15}$NO$_2$	78.68 (78.89)	5.21 (5.19)	4.73 (4.84)	8.75	7.75	8.44	4.45	8.75
10b (2-CH$_3$)	75	182-183 (ethanol)	C$_{20}$H$_{17}$NO$_2$	79.35 (79.21)	5.76 (5.61)	4.54 (4.62)	8.49	7.47	8.31	4.45	8.52
10c (2-OCH$_3$)	64	192-193 (ethanol)	C$_{20}$H$_{17}$NO$_3$	74.89 (75.24)	5.37 (5.33)	4.30 (4.39)	7.91	7.46	8.32	4.42	7.74
10d (2-Cl)	87	185-186 (ethanol)	C$_{19}$H$_{14}$ClNO$_2$	70.15 (70.48)	4.29 (4.33)	4.12 [b] (4.33)	8.70	7.75	8.35	4.45	8.39

[a] Calculated values in parenthesis. [b] Cl, 11.03 (10.97).

(s, OCH_3), 4.38 (q, CH_2), 6.90 (m, 2H, aromatics), 7.34 (m, 2H, aromatics), 7.91 (s, azomethine-H); ms: m/e 207 (M⁺, 18%), 134 (100%), 107, 77. Compound 3d had nmr: δ 1.42 (t, CH_3, J = 7.0), 4.43 (q, CH_2), 7.23 (m, 2H, aromatics), 7.40 (m, 2H, aromatics), 7.90 (s, azomethine-H); ms: m/e 211 (M⁺, 17%), 138 (100%), 111, 75. Compound 3e was present in the complex crude mixtures (see Results and Discussion). Its methanol adduct 4 obtained when using methanol as solvent, gave the following spectral data; nmr: δ 1.38 (t, CH_3, J = 7.0), 3.50 (s, OCH_3), 4.36 (q, CH_2), 5.27 (d, CH, J = 6.7), 5.78 (broad d, NH), 6.81 (m, 2H, aromatics), 8.15 (m, 2H, aromatics); ms: m/e 222 (M⁺-MeOH, 10%), 149 (100%), 103, 76.

Isolation of Ethyl 2,2-bis(4-Nitrophenylamino)acetate 5.

A solution containing 1.2 g of ethyl glyoxylate hydrate (10 mmoles) and 2.8 g of 4-nitroaniline (20 mmoles) in 20 ml of toluene was refluxed for 0.5 hour. The yellow precipitate was collected by filtration giving compound 5 (2.63 g, 76%), mp 193-195° dec: nmr δ 1.29 (t, CH_3, J = 7.3), 4.34 (q, CH_2), 5.26 (d, NH, J = 6.1), 5.45 (t, CH), 6.72 (m, 2H, aromatics), 8.15 (m, 2H, aromatics); ms: m/e 222 (M⁺-ArNH₂, 10%), 149 (100%), 103, 76.

Anal. Calcd. for $C_{16}H_{16}O_6N_4$: C, 53.33; H, 4.44; N, 15.55. Found: C, 53.29; H, 4.32; N, 15.64.

Addition of Anils 3a-f to Dihydrofuran. Formation of Substituted 4-Carboxyethyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinolines 6 and 7.

To a solution of anils 3a-f (10 mmoles) in 20 ml of anhydrous methylene chloride boron trifluoride etherate (1 mmole) and then 0.90 ml (12 moles) of dihydrofuran were added under stirring at room temperature. After 10 minutes the reaction mixture was poured into a dilute sodium hydrogen carbonate solution (10 ml). The organic layer was separated and dried over sodium sulfate. The solvent was removed under reduced pressure. Chromatography on a silica gel column (toluene/ethyl acetate) afforded compounds 6a-f and 7a-e. Compound 7f, present as minor component in the respective reaction mixture and having the same R_f of the major isomer could not be isolated in pure state.

Crystallization of the reaction crude gave pure 6f. Yields, analytical data and selected nmr frequencies for compounds 6a-f, and 7a-e, are reported in Table I and II respectively. The complete description of the proton nmr spectrum of compounds 6d and 7d is reported as an example. Compound 6d had nmr: δ 1.33 (t, CH_3, J = 7.0), 1.92 (m, H-3 and H-3'), 3.09 (m, H-3a), 3.80 (m, H-2 and H-2'), 4.19 (d, H-4, J (3a,4) = 3.4), 4.29 (m, diastereotopic CH_2-CH_3 and H-5), 5.15 (d, H-9b, J (3a,9b) = 7.9), 6.54 (d, H-6, J (6,7) = 8.5), 7.02 (dd, H-7, J (7,9) = 2.4), 7.27 (d, H-9). Compound 7d had nmr: δ 1.32 (t, CH_3, J = 7.2), 2.26 (m, H-3 and H-3'), 2.63 (m, H-3a), 3.62 (d, H-4, J (3a,4) = 9.0), 3.85 and 3.97 (m, H-2 and H-2'), 4.27 (2q, diastereotopic CH_2-CH_3), 4.43 (broad s, H-5), 4.60 (d, H-9b, J (3a,9b) = 6.0), 6.61 (d, H-6, J (6,7) = 8.6), 7.07 (dd, H-7, J (7,9) = 2.5), 7.31 (d, H-9). Compounds 6 and 7 exhibit typical ms with parent peak of about 20% and base peak from loss of carbethoxy radical.

Oxidation of Compounds 6a-f. Synthesis of Substituted 6-Carboxyethyl-furo[3,2-c]quinolines 8a-f.

General Procedure.

To a solution of 6a-f (5 mmoles) in 30 ml of toluene 2.3 g (10 mmoles) of DDQ was added under stirring. After 15 minutes at room temperature for 6b,c, 1 hour at reflux for 6a,d and 3 hours at reflux for 6e,f, the reaction mixture was filtered. The solid was washed several times with toluene and the filtrates combined. The solvent was removed under reduced pressure and the residue was crystallized. Yields, analytical data and selected nmr frequencies for compounds 8a-f are reported in Table III. The complete description of the proton nmr spectrum of compound 8d is reported as an example; δ 1.49 (t, CH_3, J = 7.0), 3.76 (t, H-3 and H-3', J (3,2) = 9.2), 4.54 (q, CH_2), 4.93 (t, H-2 and H-2'), 7.63 (dd, H-7, J (6,7) = 9.2, J (7,9) = 2.4) 7.94 (d, H-9), 8.15 (d, H-6).

Synthesis of Substituted 6-Carboxyethyl-5,6,6a,11b-tetrahydro-7H-indeno[2,1-c]quinolines 9a-f.

General Procedure.

To a solution of anils 3a-f (10 mmoles) in 20 ml of anhydrous dichloromethane boron trifluoride etherate (1 mmoles) and then 1.4 ml (12 mmoles) of indene were added with stirring at room temperature. After 2 hours the reaction mixture was poured into a dilute sodium hydrogen carbonate solution (10 ml). The organic layer was dried over sodium sulfate then the solvent was removed under reduced pressure. The residue was crystallized. Yields, analytical data and selected nmr frequencies for compounds 9a-f are reported in Table IV. The complete description of the proton nmr spectrum of compound 9d is reported as an example; δ 1.32 (t, CH_3, J = 7.2), 2.77 (dd, H-7', J (7,7') = 15.3, J (6a, 7') = 7.8), 3.12 (dd, H-7, J (6a,7) = 10.2), 3.49 (dddd, H-6a, J (6,6a) = 3.5, J (6a,11b) = 8.1), 4.21 (d, H-6), 4.29 (m, diastereotopic CH_2-CH_3), 4.36 (broad s, H-5), 4.45 (d, H-11b), 6.53 (d, H-4, J (3,4) = 8.4), 6.91 (dd, H-3, J (1,3) = 2.3), 7.18 (m, 3H), 7.24 (dd, H-1, J (1,11) = 0.92), 7.48 (m, H-11). Compounds 9a-f exhibit typical ms with parent peak of about 20% intensity and base peak from loss of carbethoxy radical.

Oxidation of Compounds 9. Synthesis of Substituted 6-Carboxyethyl-7H-indeno[2,1-c]quinolines 10a-d.

General Procedure.

To a solution of 9a-d (5 mmoles) in 30 ml of toluene, 2.3 g (10 mmoles) of DDQ was added under stirring. The resulting solution was refluxed for 5 minutes and then filtered. The solid was washed several times with toluene and the filtrates combined. Evaporation of the solvent under reduced pressure afforded a crude which was crystallized from ethanol. Yields, analytical data and selected nmr frequencies for compounds 10a-d are reported in Table V. As an example we report the complete description of the proton nmr spectrum of compound 10d; δ 1.56 (t, CH_3, J = 7.2), 4.45 (s, H-7 and H-7'), 4.62 (q, CH_2), 7.56 (m, H-9 and H-10), 7.75 (dd, H-3, J (3,4) = 9.2, J (3,1) = 2.3), 7.74-7.76 (m, H-8), 8.35 (d, H-4), 8.39 (m, H-11), 8.70 (d, H-1). Compounds 10a-d exhibit typical ms with parent peak in the 10-20% range and base peak from loss of carbethoxy radical.

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