Reaction of 3-Aminoquinoline-2,4-diones with Isocyanates. Synthesis of Novel 3-(3´-Alkyl/arylureido)quinoline-2,4-diones and Their Cyclic Carbinolamide Isomers

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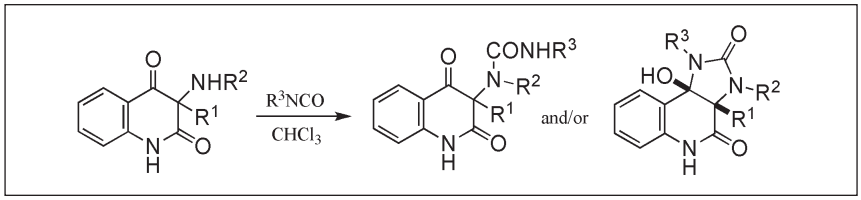

3-Alkyl/aryl-3-amino-1*H*,3*H*-quinoline-2,4-diones react with alkyl/aryl isocyanates to give novel 3-alkyl/aryl-3-ureido-1*H*,3*H*-quinoline-2,4-diones or 3a-alkyl/aryl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-diones. In some cases, a mixture of both products was obtained and separated by fractional crystallization. All compounds were characterized by their ^{1}H, ^{13}C, ir and ms data and some of them also by ^{15}N nmr data.

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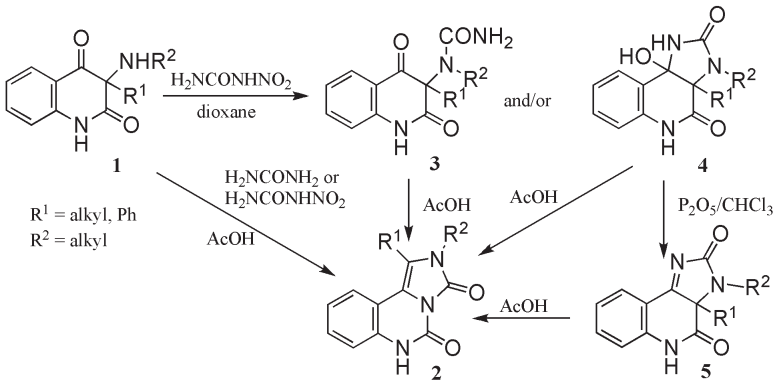
Recently, an unprecedented reaction of 3-amino-1*H*,3*H*-quinoline-2,4-diones (**1**) with urea in boiling acetic acid have been described [1]. The expected 3,3a-dihydro-5*H*-imidazo[4,5-*c*]-quinoline-2,4-diones (**5**) do not arise but a molecular rearrangement takes place, producing novel 2,6-dihydro-imidazo[1,5-*c*]quinazoline-3,5-diones (**2**) (Scheme 1). On the contrary, compounds **1** substituted at the lactame nitrogen with alkyl or aryl group react otherwise to give three different types of compounds [2]. Depending on the character of substitution in starting compounds **1**, either a molecular rearrangement of the quinolone system to indolinone system comes about with formation of 3-(3-acylureido)-2,3-dihydro-1*H*-indol-2-ones or 4-alkylidene-1´*H*-spiro[imidazolidine-5,3´-indole]-2,2´-diones, or expected 3,3*a*-dihydro-5*H*-imidazo[4,5-*c*]quinoline-2,4-diones (**5**) arise.

In our recent paper [3] we described that α-aminoketones **1** react with nitrourea in various manner depending on the character of reaction medium. Products **2** are formed in acetic acid, but novel 3-alkyl/aryl-3-ureido-1*H*,3*H*-quinoline-2,4-diones (**3**) or 3a-alkyl/aryl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-diones (**4**) are produced in dioxane or aqueous dioxane. In some cases, equilibrium was observed between **3** and **4**. Dehydration of compounds **4** yields highly unstable 3a-alkyl/aryl-3,3a-dihydro-5*H*-imidazo[4,5-*c*]quinoline-2,4-diones (**5**). Compounds **3**, **4**, and **5** rearrange to imidazoquinazoline derivatives **2** by boiling in acetic acid.

Owing to the unexpected course of substances 1 reacting with nitrourea in dioxane to produce new heterocyclic system 4, we also decided to study reactions of these α-

Scheme 1



aminoketones with some organic isocyanates. Our aim in the first place was to find out whether corresponding N(3´)-substituted analogues of 3-ureido derivatives 3 would form, or also analogues to their cyclic carbinolamide isomers 4. Our further objective on the one hand was research into the effect of substituents in starting amines 1 on the course of the reaction, and at the same time on the other, preparation of a suitable starting material for subsequent study of the molecular rearrangement that may be anticipated with this type of compounds.

Results and Discussion.

Reaction of aminoketones **1a-g** [4] with butyl isocyanate and phenyl isocyanate were performed in a chloroform solution at room temperature (Scheme 2). Results are presented in Table l.

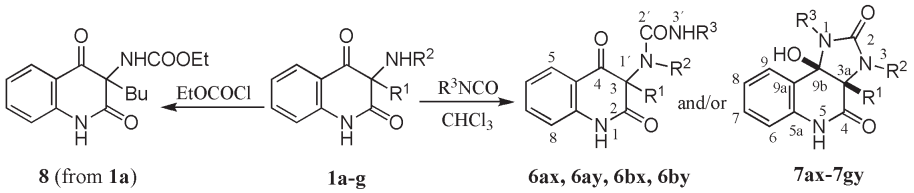
The first to be studied was the reaction of **1a** with butyl isocyanate. The raw reaction product displayed two spots well discernible by tlc. Contrary to unsuccessful attempts [3] at separating the mixture of two analogous compounds (**3** and **4**) from the reaction of **1a** with nitrourea, our attempts at separating the individual compounds through repeated fractional crystallisation were successful. The compound isolated through repeated crystallization from ethyl acetate is the anticipated 3-ureido derivative **6ax**, analogous to compound **3** prepared in our former work [3] by reacting **1a** with nitrourea. Its structure followed from study of nmr spectra (Table 2): the ^{13}C chemical shift of C=O is a typical feature of compound **6ax** and a suitable starting point for analyses of 2D experiments (gradient-selected (gs)-COSY, gs-HMQC, gs-HMBC) allowing the assignment of all proton and carbon resonances.

The second reaction product, isolated from reaction mixture through repeated crystallization from chloroform, exhibits fundamentally different nmr spectra from those of compound **6ax**. Compound **7ax** does not display any signal corresponding to keto group and shows instead a signal of sp^3 hybridised carbon atom at 86.9 ppm (Table 3). In the ^1H nmr spectrum, this compound displays a resonance corresponding to hydroxyl group proton. This indicates the compound has structure **7ax** analogous to compounds **4** obtained in our previous work [3] by reacting aminoketones **1b-f** with nitrourea. The structure of **7ax** was supported by complete interpretation of 2D experiments results (gradient-selected (gs)-COSY, gs-HMQC, gs-HMBC). *Cis*-orientation of OH group and R^1 substituents at C-3a and C-9b was confirmed by 1D gs NOESY spectrum.

Similar results were obtained from the reaction of aminoketone **1b** with butyl isocyanate: fractional crystallisation of the raw reaction product yielded compounds **6bx** and **7bx** whose nmr spectra (Tables 2 and 3) are analogous to spectra of compounds **6ax** and **7ax**. All signals were again assigned to respective atoms on the basis of 2D nmr experiments. Moreover, the differentiation and assignment of NH signals and OH resonances were performed using gs 1D and 2D ^1H-^{15}N HMQC and HMBC.

Reaction of **1a** with phenyl isocyanate produced only one compound, ureido derivative **6ay**. A sole product **6by** was also isolated from a reaction of **1b** with phenyl isocyanate.

Scheme 2



6, 7	ax	ay	bx	by	cx	cy	dx	dy	ex	ey	fx	fy	gx	gy
R^1	Bu	Bu	Ph	Ph	Bu	Bu	Bu	Bu	Bu	Bu	Ph	Ph	Ph	Ph
R^2	H	H	H	H	Me	Me	Bu	Bu	CH_2Ph	CH_2Ph	Bu	Bu	CH_2Ph	CH_2Ph
R^3	Bu	Ph	Bu	Ph	Bu	Ph	Bu	Ph	Bu	Ph	Bu	Ph	Bu	Ph

Table 1

Reaction of α-Aminoketones **1a-g** with Butyl and Phenyl Isocyanate

Entry	Starting compound **1**			Reagent R^3NCO		Product (yield %)
		R^1	R^2		R^3	
1	**1a**	Bu	H	**x**	Bu	**6ax** (23), **7ax** (43)
2	**1a**	Bu	H	**y**	Ph	**6ay** (83)
3	**1b**	Ph	H	**x**	Bu	**6bx** (24), **7bx** (57)
4	**1b**	Ph	H	**y**	Ph	**6by** (47)
5	**1c**	Bu	Me	**x**	Bu	**7cx** (82)
6	**1c**	Bu	Me	**y**	Ph	**7cy** (62)
7	**1d**	Bu	Bu	**x**	Bu	**7dx** (61)
8	**1d**	Bu	Bu	**y**	Ph	**7dy** (86)
9	**1e**	Bu	CH_2Ph	**x**	Bu	**7ex** (90)
10	**1e**	Bu	CH_2Ph	**y**	Ph	**7ey** (95)
11	**1f**	Ph	Bu	**x**	Bu	**7fx** (78)
12	**1f**	Ph	Bu	**y**	Ph	**7fy** (56)
13	**1g**	Ph	CH_2Ph	**x**	Bu	**7gx** (93)
14	**1g**	Ph	CH_2Ph	**y**	Ph	**7gy** (60)

Table 2

^{1}H, ^{13}C, and ^{15}N Chemical Shifts (δ, ppm) of Compounds **6ax**, **6ay**, **6bx**, **6by**, and **8** in DMSO-d_6

	6ax		**6ay**		**6bx**		**6by**		**8**	
Position	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N
1	10.80	[a]	10.95 [b]	–246.0 [b]	11.18	[a]	11.26 [c]	–245.3 [c]	10.94 [d]	–246.1 [d]
2	–	172.4	–	172.0	–	171.3	–	170.8	–	171.7
3	–	66.8	–	67.7	–	70.8	–	70.9	–	68.3
4	–	194.8	–	194.3	–	192.4	–	192.1	–	194.3
4a	–	119.1	–	118.9	–	118.8	–	118.8	–	119.0
5	7.79	126.8	7.82	127.0	7.77	127.5	7.81	127.6	7.80	127.0
6	7.13	122.1	7.16	122.5	7.14	122.5	7.16	122.8	7.18	122.6
7	7.62	135.7	7.66	136.1	7.64	136.1	7.67	136.4	7.58	136.3
8	7.14	116.2	7.18	116.4	7.18	116.4	7.21	116.6	7.15	116.5
8a	–	141.8	–	141.8	–	141.4	–	141.4	–	141.8
1´ (R^1)	1.74	36.5	1.81	36.3	-	134.9	-	139.4	1.76	36.4
	1.71									
2´ (R^1)	1.21	24.6	1.27	24.7	7.42	126.7	7.45	126.7	1.22	24.7
	1.15									
3´ (R^1)	1.22	22.2	1.25	22.2	7.42	129.0	7.43	129.4	1.20	22.2
4´ (R^1)	0.80	13.7	0.84	13.8	7.42	129.1	7.43	129.4	0.77	13.7
1´	6.86	[a]	7.21 [e]	–282.4 [e]	7.25	[a]	7.59 [f]	–279.2 [f]	8.23 [g]	–286.0 [g]
2´	–	157.2	–	154.6	–	157.6	–	154.8	–	156.1 [h]
3´	6.04	[a]	8.68 [i]	–276.2 [i]	6.25	[a]	8.76 [j]	–275.6 [j]	–	–
1´ (R^3)	2.93	39.0	–	139.8	2.99	39.0	–	134.2	–	–
2´ (R^3)	1.34	32.1	7.34	117.7	1.38	32.1	7.37	117.7	–	–
3´ (R^3)	1.27	19.5	7.23	128.8	1.31	19.5	7.27	128.9	–	–
4´ (R^3)	0.89	13.7	6.94	122.4	0.91	13.8	6.97	121.8	–	–

[a] Not measured; [b] $^1J(^{15}N, ^1H)$ (Hz): 90.9; [c] $^1J(^{15}N, ^1H)$ (Hz): 90.4; [d] $^1J(^{15}N, ^1H)$ (Hz): 90.8; [e] $^1J(^{15}N, ^1H)$ (Hz): 92.1; [f] $^1J(^{15}N, ^1H)$ (Hz): 92.0; [g] $^1J(^{15}N, ^1H)$ (Hz): 95.3; [h] 3.96/60.5 (CH_2O), 1.20/14.6 (CH_3); [i] $^1J(^{15}N, ^1H)$ (Hz): 89.0; [j] $^1J(^{15}N, ^1H)$ (Hz): 89.2.

On the other hand, all reactions of aminoketones **1c-1g** with butyl isocyanate as well as with phenyl isocyanate ran unambiguously to form cyclic amidocarbinols **7cx-7gy** whose nmr spectra are presented in Tables 3 and 4.

In accordance with our previous works [1-3], all studied compounds provided $[M+H]^+$ ions in the positive-ion APCI ms spectra and $[M-H]^-$ ions in the negative-ion APCI mode, which enabled an unambiguous determination of molecular weights of individual compounds. The fragmentation behaviour also followed the characteristic pattern with the neutral losses as water (Δ *m/z* 18), NHCO (43), NH_2CO (44), butene (56), butylamine (73), benzene (78), butylisocyanate (99), phenylisocyanate (119), *etc*. Typically, the base peak or at least the peak of very abundant ion in tandem ms is the ion corresponding to the neutral loss of substituent in the position N-3´ in the form of R^3NCO, *e.g*., phenyl- or butylisocyanate. An interesting rearrangement reaction occurred for R^2 = benzyl substituted derivatives yielding $[C_6H_5CH_2NH_2R^3]^+$ ions, *e.g*., $[C_6H_5CH_2NH_2CH_2CH_2CH_2CH_3]^+$ at *m/z* 164 for **7ex** and **7gx** or $[C_6H_5CH_2NH_2C_6H_5]^+$ at *m/z* 184 for **7ey**. The character of these ions was confirmed by ms^n experiments. Unfortunately, APCI-ms cannot distinguish between **6** and **7** compounds series, because both spectra are identical, *e.g*. **6ax** and **7ax**.

From results in Table 1 it is obvious that significant formation of ureido derivatives **6** occurs merely when employing such starting compounds **1** that bear a primary amino group in position 3 (R^2 = H). If a phenyl group is present at N-3´ of ureido group (**6ay**, **6by**, R^3 = Ph), the cyclization to the corresponding amidocarbinol **7** does not proceed. However, if the substituent at N-3´ is a butyl group with positive inductive effect (**6ax**, **6bx**, R^3 = Bu), nitrogen atom N-3´ becomes a stronger nucleophile, easily adds to carbonyl group in position 4 and a mixture of ureido derivative **6** and carbinolamide **7** is formed. From Table 1 it is also apparent that when employing starting compounds **1** bearing a secondary amino group in position 3 ($R^2 \neq$ H), cyclic carbinolamide isomers **7** arise from **1** as the only isolable product heedless of the substituent at N-3´ (R^3) being a butyl or phenyl group.

Similarly to our previous work [3], we indicated the presence of two compounds in all raw products from the reaction of **1a** and **1b** with both isocyanates by means of tlc (mainly when employing elution system S5), which is probably due to equilibrium between acyclic and cyclic forms **6** and **7**. The analogous formation of an equilibrium mixture of cyclic and acyclic isomers during hydration of 4-oxoazetidines substituted with a carbamoylthioacetyl group in position 2 was described by Sápi *et al*. [5]. On the other hand, formation of cyclic isomers of 3-alkyl/aryl-1*H*,3*H*-quinoline-2,4-diones substituted with a carbamoylthio group in position 3 was not observed [6].

Table 3

^{1}H, ^{13}C, and ^{15}N Chemical Shifts (δ, ppm) of Compounds **7ax-7dy** in DMSO-d_6

	7ax		**7bx**		**7cx**		**7cy**		**7dx**		**7dy**	
Position	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N	δ_H	δ_C or δ_N
1	-	[a]	-	-266.9	-	[a]	-	[a]	-	[a]	-	[a]
2	-	159.7	-	160.1	-	158.5	-	-	-	158.6	-	-
3	7.22	[a]	7.82	-293.1 [b]		[a]	-	[a]	-	[a]	-	[a]
3a	-	65.2	-	68.9		66.9	-	67.5	-	67.6	-	68.6
4	-	171.7	-	171.0	-	171.1	-	171.0	-	171.2	-	171.4
5	10.55	[a]	10.91	-246.5 [c]	10.53	[a]	10.67	[a]	10.50	[a]	10.63	[a]
5a	-	135.5	-	135.8	-	135.3	-	135.6	-	135.3	-	135.3
6	6.94	115.1	7.10	115.5	6.94	115.0	6.94	115.0	6.92	114.9	6.92	115.2
7	7.34	129.9	7.43	130.4	7.33	130.0	7.24	130.1	7.33	129.9	7.24	130.3
8	7.10	122.4	7.15	122.9	7.10	122.6	6.81	122.1	7.10	122.7	6.81	122.4
9	7.72	127.1	7.67	127.9	7.70	126.7	7.13	126.9	7.75	126.7	7.14	127.1
9a	-	122.1	-	121.7	-	122.5	-	121.8	-	122.4	-	122.1
9b	-	86.9	-	87.9	-	86.4	-	88.0	-	86.1	-	86.1
1´ (R^1)	1.76	31.2	-	135.3	1.99	29.9	2.12	30.2	1.92	30.7	2.02	31.1
	1.72				1.83		1.95		1.89		1.97	
2´ (R^1)	1.10	25.1	7.27	126.5	1.13	24.3	1.16	24.5	1.12	24.4	1.15	24.7
					0.91		0.95		0.92		1.10	
3´ (R^1)	1.16	22.8	7.30	128.1	1.20	22.7	1.23	22.7	1.20	22.6	1.21	22.9
4´ (R^1)	0.77	13.7	7.30	127.1	0.74	13.6	0.76	13.8	0.74	13.6	0.74	13.6
1´ (R^2)	-	-	-	-	3.42	26.8	3.13	27.1	3.57	41.2	3.57	41.6
									3.43		3.46	
2´ (R^2)	-	-	-	-	-	-	-	-	1.61	32.8	1.68	33.0
									1.52		1.57	
3´ (R^2)	-	-	-	-	-	-	-	-	1.35	19.9	1.39	20.3
4´ (R^2)	-	-	-	-	-	-	-	-	0.95	14.0	0.95	14.0
1´ (R^3)	3.04	37.7	3.13	37.8	3.07	37.6	-	135.0	3.10	37.6	-	135.8
	2.88		2.89		2.88				2.87			
2´ (R^3)	0.86	31.2	0.89	31.1	0.83	31.2	6.85	129.7	0.81	31.2	6.85	129.8
3´ (R^3)	0.95	19.0	0.98	19.1	0.91	19.0	7.21	128.1	0.92	19.0	7.20	128.4
	0.86		0.89		0.83				0.81			
4´ (R^3)	0.61	13.6	0.64	13.1	0.60	13.6	7.21	127.6	0.60	13.6	7.20	128.0
OH	6.51	-	6.33	-	6.58	-	7.16	-	6.45	-	7.06	-

[a] Not measured; [b] $^1J(^{15}N, ^1H)$ (Hz): 92.1; [c] $^1J(^{15}N, ^1H)$ (Hz): 90.0.

Equilibrium may be influenced by a change in solvent, and in that way we also succeeded in separating isomeric couples of **6ax** and **7ax**, or **6bx** and **7bx** through fractional crystallisation from two different solvents. Presence of two compounds was proved by means of tlc also in raw products of the reaction of **1a** and **1b** with phenyl isocyanate. In these cases, however, equilibrium got disturbed in all employed solvents due to crystallisation of less soluble ureido derivatives **6ay** or **6by**, while a roughly same representation of both isomers always remained in mother liquors after repeated crystallisations. This is the reason of our failure to isolate the cyclic isomers **7ay** or **7by**. According to tlc, in a reaction of **1c-1g** with butyl isocyanate or phenyl isocyanate both isomers also arise, but cyclic form **7** is unambiguously dominant in the crude reaction product, and isolating the ureido derivative did not succeed in a single case.

We also made an effort to influence equilibrium between **6** and **7** by means of basic catalysis. We found that pure compound **6ax** after a 4-hour boiling in acetone in the presence of a catalytic quantity of triethylamine changes to a mixture of **6ax** and **7ax** in an approximate 1:1 ratio. The same mixture of isomers was obtained under identical conditions also when the employed starting compound was pure **7ax**. In attempts to influence equilibrium by acid catalysis (*p*-toluenesulphonic acid in benzene), complicated mixtures of not less than five compounds arose. Under these conditions, a molecular rearrangement probably occurs similar to the rearrangement taking place when reacting amines **1** with urea in acetic acid [1,2], or when boiling compounds **3** and **4** in acetic acid [3]. Transformation of compounds **6** and **7** already take place with ease through boiling in acetic acid, as was found in preliminary experiments. At present, we are working on the problem.

Compounds **6** and **7** are unstable not only in an acidic environment, but also under thermal load. Their transformations on heating result in a relatively wide range of melting points despite their chromatographic purity. In all cases, tlc analysis of residues after determining melting points of compounds **6** and **7** proves their thermal transformation to hitherto unknown compounds proceeds.

Table 4

^{1}H and ^{13}C Chemical Shifts (δ, ppm) of Compounds **7ex-7gy** in DMSO-d_6

	7ex		**7ey**		**7fx**		**7fy**		**7gx**		**7gy**	
Position	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C
2	-	159.0	-	157.7	-	160.3	-	158.7	-	160.7	-	159.2
3a	-	67.8	-	68.5	-	73.9	-	74.5	-	74.1	-	74.7
4	-	171.4	-	171.2	-	170.6	-	170.4	-	170.9	-	170.6
5	10.62	-	10.76	-	11.00	-	11.12	-	11.14	-	11.26	-
5a	-	135.4	-	135.1	-	135.5	-	135.2	-	135.5	-	135.3
6	6.95	115.0	6.97	115.0	7.06	115.3	7.10	115.3	7.11	115.5	7.15	115.4
7	7.35	130.1	7.21	130.2	7.37	130.3	7.28	130.4	7.41	130.5	7.32	130.6
8	7.14	122.5	6.86	121.9	7.05	122.6	6.81	122.2	7.09	122.9	6.85	122.3
9	7.76	126.9	7.26	127.8	7.55	128.3	7.10	129.0	7.60	128.3	7.12	128.7
9a	-	122.3	-	121.7	-	121.0	-	120.2	-	121.1	-	120.3
9b	-	86.4	-	88.0	-	87.5	-	89.0	-	87.7	-	89.2
1´ (R^1)	1.76	30.5	1.86	30.6	-	133.0	-	132.8	-	132.6	-	132.9
	1.72		1.83									
2´ (R^1)	1.06	24.4	1.07	24.5	7.39	128.1	7.43	128.1	7.24	128.1	7.30	128.0
	0.96		0.96									
3´ (R^1)	1.06	22.4	1.07	22.5	7.35	128.0	7.39	128.0	7.24	128.0	7.27	128,2
4´ (R^1)	0.62	13.5	0.64	13.5	7.35	128.0	7.39	129.0	7.28	128.6	7.35	129.1
1´ (R^2)	4.93	44.1	5.03	44.4	3.36	44.6	3.46	44.8	4.76	47.5	4.87	47.2
	4.79		4.89		3.01		3.10		4.42		4.51	
2´ (R^2)	-	140.7	-	140.4	2.05	31.1	2.10	31.1	-	139.8	-	139.4
					1.65		1.74					
3´ (R^2)	7.44	126.9	7.54	127.0	1.28	20.2	1.31	20.2	7.49	127.3	7.56	127.3
					1.22		1.24					
4´ (R^2)	7.35	128.0	7.39	128.0	0.86	13.9	0.92	13.9	7.36	128.0	7.40	128.0
5´ (R^2)	7.25	126.4	7.29	126.5	-	-	-	-	7.28	126.3	7.32	126.4
1´ (R^3)	3.20	37.9	-	135.8	3.20	38.1	-	135.8	3.26	38.7	-	135.8
	2.93				2.86				2.94			
2´ (R^3)	0.83	31.1	6.94	129.5	0.86	31.1	6.97	128.8	0.88	31.0	7.01	128.9
3´ (R^3)	0.95	18.9	7.24	128.0	0.95	19.0	7.24	128.0	0.97	19.1	7.27	128.2
	0.87				0.86				0.89			
4´ (R^3)	0.62	13.5	7.24	126.7	0.63	13.5	7.18	126.6	0.64	13.6	7.21	126.7
OH	6.52	-	6.90	-	6.47	-	6.98	-	6.55	-	7.00	-

Expecting that a thermally initiated or acid-catalyzed molecular rearrangement might proceed not only with compounds of type **3** and **6** but also with related carbamic acid esters, we prepared model compound **8** through the reaction of amine **1a** with ethyl chloroformate (Scheme 2). Compound **8**, however, does not change by boiling in acetic acid even after addition of ammonium acetate, and in an attempt at thermal rearrangement in boiling cyclohexylbenzene in the presence of catalytic quantity of 4-dimethylaminopyridine it yields a complex mixture of compounds which chromatography fails to separate. Hence, compounds of type **8** are not suitable for studying further transformations of N-1´ substituted 3-aminoquinolinediones.

EXPERIMENTAL

The melting points were determined on a Kofler block or Gallencamp apparatus. The ir spectra were recorded on a Mattson 3000 spectrophotometer using samples in potassium bromide disks. The nmr spectra were recorded on a Bruker Avance spectrometer (500.13 MHz for ^{1}H, 125.76 MHz for ^{13}C, 50.68 MHz for ^{15}N) in DMSO-d_6. ^{1}H and ^{13}C chemical shifts are given on the δ scale (ppm) and are referenced to internal TMS. ^{15}N chemical shifts were referred to external neat nitromethane in co-axial capillary (δ = 0.0). All 2D experiments (gradient-selected (gs)-COSY, NOESY, gs-TOCSY, gs-HMQC, gs-HMBC) were performed using manufacturer's software. Proton spectra were assigned using gs-COSY. Protonated carbons were assigned by gs-HMQC. Quaternary carbons were assigned by gs-HMBC. The positive-ion APCI mass spectra were measured on an ion trap analyser Esquire 3000 (Bruker Daltonics, Bremen, Germany) within the mass range *m/z* = 50 - 500. Samples were dissolved in acetonitrile and analysed by direct infusion at the flow rate of 50 µl/min. The ion source temperature was 350 °C, the APCI probe temperature was 350 °C, the flow rate and the pressure of nitrogen were 4 l/min and 45 psi, respectively. For ms/ms measurements, the isolation width of precursor ions was 4 *m/z* and the collision amplitude was 0.8 V. Column chromatography was carried out on Silica gel (Merck, grade 60, 70-230 mesh) using benzene and then successive mixtures of benzene-ethyl acetate (in ratios from 99:1 to 8:2, solvent system S1). Reactions as well as the course of separation and also the purity of substances were monitored by tlc (elution systems benzene-ethyl acetate, 4:1 (S2), chloroform-ethanol, 9:1 (S3) and/or 19:1 (S4)), and chloroform-isopropylalcohol, 9:1 (S5) on Alugram® SIL G/UV_{254} foils (Macherey-Nagel). Elemental analyses (C, H, N) were performed with an EA 1108 Elemental Analyzer (Fisons Instrument).

3-Amino-1*H*,3*H*-quinoline-2,4-diones (**1a-f**) were prepared according to the general procedure described in literature [4].

General Procedure for the Preparation of 3´-Substituted 3-Ureido-1*H*,3*H*-quinoline-2,4-diones (**6**) and 1-Substituted 3a-alkyl/aryl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-diones (**7**).

Phenyl isocyanate (0.130 ml, 1.2 mmoles) or butyl isocyanate (0.135 ml, 1.2 mmoles) was added to the cooled (0 °C) and stirred solution of **1** (1 mmol) in chloroform (5 ml). After 2 h at rt, the precipitate was collected by filtration with suction and crystallized from appropriate solvent (compounds **6ay**, **7dx**, **7dy**, **7fx** and **7fy**). In cases of mixtures of compounds **6ax-7ax** and **6bx-7bx**, the mixture was separated by repeated fraction crystallization using chloroform and ethyl acetate. In cases when the product was soluble in chloroform (**7cx**, **7cy**, **7ex**, **7ey**, **7gx**, and **7gy**), the solution was evaporated *in vacuo* to dryness and the residue was crystallized from appropriate solvent. In some cases, the mother liquors were column chromatographed using solvent system S1.

3-Butyl-3-(3-butylureido)-1*H*,3*H*-quinoline-2,4-dione (**6ax**).

This compound was obtained as colourless crystals, 76 mg (23%), mp 191-196 °C (ethyl acetate); ir: ν 3373, 3251, 2959, 2930, 2862, 1698, 1673, 1637, 1613, 1559, 1487, 1467, 1380, 1296, 1285, 1183, 1154, 1113, 948, 776, 666, 564, 528, 485 cm^{-1}; positive-ion APCI-ms: *m/z* 332 $[M+H]^+$, 314 $[M+H-H_2O]^+$, 288 $[M+H-NH_2CO]^+$, 259 $[M+H-CH_3CH_2CH_2CH_2NH_2]^+$, 233 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 215 $[M+H-CH_3CH_2CH_2CH_2NCO-H_2O]^+$; positive-ion APCI-ms/ms of *m/z* 332: *m/z* 233 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 215 $[M+H-CH_3CH_2CH_2CH_2NCO-H_2O]^+$; negative-ion APCI-ms: *m/z* 330 $[M-H]^-$ (100%), 312 $[M-H-H_2O]^-$, 257 $[M-H-CH_3CH_2CH_2CH_2NH_2]^-$, 231 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$, 213 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$, 174 $[M-H-CH_3CH_2CH_2CH_2NCO\text{-butyl}]^-$; negative-ion APCI-ms/ms of *m/z* 330: *m/z* 312 $[M-H-H_2O]^-$, 286 $[M-H-NH_2CO]^-$, 257 $[M-H-CH_3CH_2CH_2CH_2NH_2]^-$, 231 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$ (100%), 216 $[M-H-CH_3CH_2CH_2CH_2NCONH]^-$, 213 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$, 174 $[M-H-CH_3CH_2CH_2CH_2NCO\text{-butyl}]^-$.

Anal. Calcd. for $C_{18}H_{25}N_3O_3$: C, 65.23; H, 7.60; N, 12.68. Found: C, 65.02; H, 7.78; N, 12.51.

3-Butyl-3-(3-phenylureido)-1*H*,3*H*-quinoline-2,4-dione (**6ay**).

This compound was prepared as colourless crystals, 292 mg (83%), mp 251-264 °C (ethanol); ir: ν 3344, 3317, 3032, 2955, 2926, 2861, 1708, 1697, 1669, 1632, 1613, 1598, 1561, 1500, 1487, 1443, 1379, 1364, 1317, 1251, 1180, 853, 765, 694, 665, 629, 589 cm^{-1}; positive-ion APCI-ms and ms/ms of *m/z* 352 are the same: *m/z* 352 $[M+H]^+$, 233 $[M+H-C_6H_5NCO]^+$ (100%), 215 $[M+H-C_6H_5NCO-H_2O]^+$, 177 $[M+H-C_6H_5NCO\text{-butene}]^+$, 149 $[M+H-C_6H_5NCO\text{-butene-CO}]^+$; negative-ion APCI-ms and ms/ms of *m/z* 350 are the same: *m/z* 350 $[M-H]^-$, 257 $[M-H-C_6H_5NH_2]^-$, 231 $[M-H-C_6H_5NCO]^-$ (100%), 174 $[M-H-C_6H_5NCO\text{-butyl}]^-$, 148 $[C_6H_4NHCOCHCH_2]^+$.

Anal. Calcd. for $C_{20}H_{21}N_3O_3$: C, 68.36; H, 6.02; N, 11.96. Found: C, 68.12; H, 6.23; N, 11.81.

3-(3-Butylureido)-3-phenyl-1*H*,3*H*-quinoline-2,4-dione (**6bx**).

This compound was prepared as colourless crystals, 85 mg (24%), mp 176-180 °C (ethyl acetate); ir: ν 3385, 3237, 3196, 3090, 3065, 2957, 2930, 2871, 1710, 1675, 1614, 1597, 1557, 1487, 1449, 1367, 1322, 1271, 1253, 1231, 1194, 1158, 1113, 1038, 775, 743, 696, 665, 571, 516, 496 cm^{-1}; positive-ion APCI-ms and ms/ms of *m/z* 352 are the same: *m/z* 352 $[M+H]^+$, 253 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 236 $[M+H-CH_3CH_2CH_2CH_2NCO-NH_3]^+$, 208 $[M+H-CH_3CH_2CH_2CH_2NCO-NH_3-CO]^+$; negative-ion APCI-ms: *m/z* 350 $[M-H]^-$ (100%), 277 $[M-H-CH_3CH_2CH_2CH_2NH_2]^-$, 251 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$, 207 $[M-H-CH_3CH_2CH_2CH_2NCO-NH_2CO]^-$; negative-ion APCI-ms/ms of *m/z* 350: *m/z* 332 $[M-H-H_2O]^-$, 306 $[M-H-NH_2CO]^-$, 277 $[M-H-CH_3CH_2CH_2CH_2NH_2]^-$, 251 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$, 233 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$ (100%), 207 $[M-H-CH_3CH_2CH_2CH_2NCO-NH_2CO]^-$.

Anal. Calcd. for $C_{20}H_{21}N_3O_3$: C, 68.36; H, 6.02; N, 11.96. Found: C, 68.21; H, 6.23; N, 11.89.

3-Phenyl-3-(3-phenylureido)-1*H*,3*H*-quinoline-2,4-dione (**6by**).

This compound was prepared as colourless crystals, 177 mg (47%), mp 217-225 °C (ethyl acetate); ir: ν 3370, 3252, 1671, 1598, 1548, 1487, 1450, 1364, 1315, 1231, 1189, 1161, 851, 787, 764, 742, 690, 670, 620, 602, 576, 531, 502 cm^{-1}; positive-ion APCI-ms: *m/z* 372 $[M+H]^+$ (100%), 253 $[M+H-C_6H_5NCO]^+$, 251 $[M+H-C_6H_5NHCOH]^+$, 223 $[M+H-C_6H_5NHCOH-CO]^+$, 208 $[[M+H-C_6H_5NCO-NH_3-CO]^+$; positive-ion APCI-ms/ms of *m/z* 372: *m/z* 253 $[M+H-C_6H_5NCO]^+$ (100%), 236 $[M+H-C_6H_5NCO-NH_3]^+$, 208 $[M+H-C_6H_5NHCOH-NHCO]^+$; negative-ion APCI-ms: *m/z* 370 $[M-H]^-$, 277 $[M-H-C_6H_5NH_2]^-$, 251 $[M-H-C_6H_5NCO]^-$ (100%), 236 $[M-H-C_6H_5NHCON]^-$, 207 $[M-H-C_6H_5NCO-NH_2CO]^-$; negative-ion APCI-ms/ms of *m/z* 370: *m/z* 352 $[M-H-H_2O]^-$, 326 $[M-H-NH_2CO]^{-\cdot}$, 277 $[M-H-C_6H_5NH_2]^-$, 251 $[M-H-C_6H_5NCO]^-$ (100%), 233 $[M-H-C_6H_5NCO-H_2O]^-$.

Anal. Calcd. for $C_{22}H_{17}N_3O_3$: C, 71.15; H, 4.61; N, 11.31. Found: C, 71.23; H, 4.83; N, 11.35.

1,3a-Dibutyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7ax**).

This compound was prepared as colourless crystals, 142 mg (43%), mp 117-123 °C (chloroform); ir: ν 3248, 3066, 2959, 2932, 2872, 1692, 1600, 1493, 1450, 1414, 1376, 1218, 1125, 1076, 1045, 999, 938, 911, 759, 657, 626, 575, 543 cm^{-1}; positive-ion APCI-ms: *m/z* 332 $[M+H]^+$, 314 $[M+H-H_2O]^+$, 288 $[M+H-NH_2CO]^{+\cdot}$, 259 $[M+H-CH_3CH_2CH_2CH_2NH_2]^+$, 233 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 215 $[M+H-CH_3CH_2CH_2CH_2NCO-H_2O]^+$; positive-ion APCI-ms/ms of *m/z* 332: *m/z* 233 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 215 $[M+H-CH_3CH_2CH_2CH_2NCO-H_2O]^+$; negative-ion APCI-ms: *m/z* 330 $[M-H]^-$ (100%), 312 $[M-H-H_2O]^-$, 257 $[M-H-CH_3CH_2CH_2CH_2NH_2]^-$, 231 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$, 213 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$, 174 $[M-H-CH_3CH_2CH_2CH_2NCO\text{-butyl}]^-$; negative-ion APCI-ms/ms of *m/z* 330: *m/z* 312 $[M-H-H_2O]^-$, 286 $[M-H-NH_2CO]^-$, 257 $[M-H-CH_3CH_2CH_2CH_2NH_2]^-$, 231 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$ (100%), 216 $[M-H-CH_3CH_2CH_2CH_2NCONH]^{-\cdot}$, 213 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$, 174 $[M-H-CH_3CH_2CH_2CH_2NCO\text{-butyl}]^-$.

Anal. Calcd. for $C_{18}H_{25}N_3O_3$: C, 65.23; H, 7.60; N, 12.68. Found: C, 65.01; H, 7.77; N, 12.51.

1-Butyl-9b-hydroxy-3a-phenyl-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7bx**).

This compound was prepared as colourless crystals, 199 mg (57%), mp 178-184 °C (ethyl acetate); ir: ν 3411, 3325, 3192, 3062, 2930, 2872, 1672, 1698, 1493, 1448, 1415, 1378, 1225, 1138, 1076, 753, 703, 683, 601 cm^{-1}; positive-ion APCI-ms: *m/z* 352 $[M+H]^+$, 334 $[M+H-H_2O]^+$, 308 $[M+H-NH_2CO]^+$, 279 $[M+H-CH_3CH_2CH_2CH_2NH_2]^+$, 253 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 236 $[M+H-CH_3CH_2CH_2CH_2NCO-NH_3]^+$, 209 $[M+H-CH_3CH_2CH_2CH_2NCO-NH_3-HCN]^+$; positive-ion APCI-ms/ms of *m/z* 352: *m/z* 253 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 236 $[M+H-CH_3CH_2CH_2CH_2NCO-NH_3]^+$; negative-ion APCI-ms: *m/z* 350 $[M-H]^-$ (100%), 332 $[M-H-H_2O]^-$, 251 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$, 207 $[M-H-CH_3CH_2CH_2CH_2NCO-NH_3-HCN]^-$; negative-ion APCI-ms/ms of *m/z* 350: *m/z* 332 $[M-H-H_2O]^-$, 306 $[M-H-NH_2CO]^-$, 277 $[M-H-CH_3CH_2CH_2CH_2-NH_2]^-$, 251 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$, 234 $[M-H-CH_3CH_2CH_2CH_2NCO-NH_3]^-$ (100%), 207 $[M-H-CH_3CH_2CH_2-CH_2NCO-NH_3-HCN]^-$.

Anal. Calcd. for $C_{20}H_{21}N_3O_3$: C, 68.36; H, 6.02; N, 11.96. Found: C, 68.07; H, 6.15; N, 11.78.

1,3a-Dibutyl-3-methyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7cx**).

This compound was prepared as colourless crystals, 283 mg (82%), mp 122-140 °C (ethyl acetate); ir: ν 3211, 3078, 2957, 2931, 2859, 1690, 1676, 1619, 1600, 1493, 1453, 1431, 1401, 1377, 1214, 1125, 1081, 1042, 999, 937, 837, 761, 674, 658, 648, 628, 571, 541 cm^{-1}; positive-ion APCI-ms: *m/z* 346 $[M+H]^+$, 328 $[M+H-H_2O]^+$ (100%), 302 $[M+H-NH_2CO]^+$, 247 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$; positive-ion APCI-ms/ms of *m/z* 346: *m/z* 247 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 191 $[M+H-CH_3CH_2CH_2CH_2NCO\text{-butene}]^+$, 146 $[C_6H_4NHCOCHCH_2]^+$; negative-ion APCI-ms: *m/z* 344 $[M-H]^-$ (100%), 315 $[M-H-HCO]^{-\cdot}$, 270 $[M-H-H_2O\text{-butene}]^-$, 245 $[M-H-CH_3CH_2CH_2-CH_2NCO]^-$; negative-ion APCI-ms/ms of *m/z* 344: *m/z* 245 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$ (100%), 188 $[M-H-CH_3CH_2CH_2-CH_2NCO\text{-butyl}]^-$.

Anal. Calcd. for $C_{19}H_{27}N_3O_3$: C, 66.06; H, 7.88; N, 12.16. Found: C, 65.83; H, 8.03; N, 12.32.

3a-Butyl-3-methyl-1-phenyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7cy**).

This compound was prepared as colourless crystals, 228 mg (62%), mp 168-174 °C (ethyl acetate); ir: ν 3391, 3198, 3064, 2959, 2930, 2864, 1674, 1601, 1495, 1449, 1394, 1367, 1219, 1156, 1126, 1091, 1069, 1043, 1006, 970, 915, 853, 758, 704, 672, 652, 634, 541, 508 cm^{-1}; positive-ion APCI-ms: *m/z* 366 $[M+H]^+$ (100%), 348 $[M+H-H_2O]^+$, 322 $[M+H-NH_2CO]^+$, 247 $[M+H-C_6H_5NCO]^+$; positive-ion APCI-ms/ms of *m/z* 366: *m/z* 247 $[M+H-C_6H_5NCO]^+$ (100%), 229 $[M+H-C_6H_5NCO-H_2O]^+$, 146 $[C_6H_4NHCOCHCH_2]^+$; negative-ion APCI-ms: *m/z* 364 $[M-H]^-$, 346 $[M-H-H_2O]^-$, 290 $[M-H-H_2O\text{-butene}]^-$, 245 $[M-H-C_6H_5NCO]^-$ (100%), 188 $[M-H-C_6H_5NCO\text{-butyl}]^-$; negative-ion APCI-ms/ms of *m/z* 364: *m/z* 245 $[M-H-C_6H_5NCO]^-$ (100%), 188 $[M-H-C_6H_5NCO\text{-butyl}]^-$.

Anal. Calcd. for $C_{21}H_{23}N_3O_3$: C, 69.02; H, 6.34; N, 11.50. Found: C, 69.11; H, 6.48; N, 11.42.

1,3,3a-Tributyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7dx**).

This compound was prepared as colourless crystals, 237 mg (61%), mp 126-142 °C (chloroform); ir: ν 3336, 3344, 3207, 3082, 2957, 2931, 2872, 1691, 1678, 1602, 1497, 1465, 1438, 1421, 1376, 1363, 1334, 1314, 1212, 1165, 1125, 1080, 1062, 1041, 999, 937, 858, 807, 775, 767, 671, 615, 546, 533 cm^{-1}; positive-ion APCI-ms and ms/ms of *m/z* 388 are the same: *m/z* 388 $[M+H]^+$ (100% for MS), 370 $[M+H-H_2O]^+$, 344 $[M+H-NH_2CO]^+$, 314 $[M-H-H_2O\text{-butene}]^-$, 289 $[M+H-CH_3CH_2-CH_2CH_2NCO]^+$ (100% for ms/ms); negative-ion APCI-ms: *m/z* 386 $[M-H]^-$ (100%), 368 $[M-H-H_2O]^-$, 357 $[M-H-HCO]^-$, 312 $[M-H-H_2O\text{-butene}]^-$, 287 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$; negative-ion APCI-ms/ms of *m/z* 386: *m/z* 287 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$ (100%).

Anal. Calcd. for $C_{22}H_{33}N_3O_3$: C, 68.19; H, 8.58; N, 10.84. Found: C, 68.41; H, 8.65; N, 10.93.

3,3a-Dibutyl-1-phenyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7dy**).

This compound was prepared as colourless crystals, 349 mg (86%), mp 147-153 °C (chloroform); ir: ν 3403, 3204, 3116, 3082, 2959, 2933, 2873, 1696, 1678, 1617, 1601, 1542, 1493, 1446, 1415, 1376, 1310, 1218, 1178, 1127, 1096, 1081, 1038, 998, 802, 755, 701, 692, 669, 655, 631, 577, 558, 506 cm^{-1}; positive-ion APCI-ms: *m/z* 408 $[M+H]^+$ (100%), 390 $[M+H-H_2O]^+$, 364 $[M+H-NH_2CO]^+$, 289 $[M+H-C_6H_5NCO]^+$; positive-ion APCI-ms/ms of *m/z* 408: *m/z* 289 $[M+H-C_6H_5NCO]^+$ (100%), 271 $[M+H-C_6H_5NCO-H_2O]^+$; negative-ion APCI-ms: *m/z* 406 $[M-H]^-$ (100%), 377 $[M-H-HCO]^-$, 332 $[M-H-H_2O\text{-butene}]^-$, 287 $[M-H-C_6H_5NCO]^-$, 269 $[M-H-C_6H_5NCO-H_2O]^-$; negative-ion APCI-ms/ms of *m/z* 406: *m/z* 287 $[M-H-C_6H_5NCO]^-$ (100%).

Anal. Calcd. for $C_{24}H_{29}N_3O_3$: C, 70.74; H, 7.17; N, 10.31. Found: C, 70.61, H, 7.31, N, 10.38.

3-Benzyl-1,3a-dibutyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7ex**).

This compound was prepared as colourless crystals, 381 mg (90%), mp 99-105 °C (hexane); ir: ν 3363, 3242, 3226, 3084, 3034, 2932, 2872, 1689, 1618, 1601, 1494, 1451, 1417, 1377, 1360, 1316, 1217, 1123, 1077, 1041, 1018, 939, 849, 759, 732, 701, 670, 655, 625, 617, 545, 531 cm^{-1}; positive-ion APCI-ms: *m/z* 422 $[M+H]^+$ (100%), 404 $[M+H-H_2O]^+$, 378 $[M+H-NH_2CO]^{+\cdot}$, 348 $[M+H-H_2O\text{-butene}]^+$, 323 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$; positive-ion APCI-ms/ms of *m/z* 422: *m/z* 404 $[M+H-H_2O]^+$, 344 $[M+H-C_6H_6]^+$, 323 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 305 $[M+H-CH_3CH_2-CH_2CH_2NCO-H_2O]^+$, 245 $[M+H-CH_3CH_2CH_2CH_2NCO-C_6H_6]^+$, 164 $[C_6H_5CH_2NH_2CH_2CH_2CH_2CH_3]^+$; negative-ion APCI-ms: *m/z* 420 $[M-H]^-$ (100%), 402 $[M-H-H_2O]^-$, 391 $[M-H-HCO]^{-\cdot}$, 346 $[M-H-H_2O\text{-butene}]^-$, 321 $[M-H-CH_3CH_2-CH_2CH_2NCO]^-$; negative-ion APCI-ms/ms of *m/z* 420: *m/z* 402 $[M-H-H_2O]^-$, 321 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$ (100%), 303 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$, 230 $[M-H-CH_3CH_2CH_2CH_2NCO-C_6H_5CH_2]^-$, 216 $[C_6H_4NHCOC(butyl)CO]^-$.

Anal. Calcd. for $C_{25}H_{31}N_3O_3$: C, 71.23; H, 7.41; N, 9.97. Found: C, 71.45; H, 7.57; N, 10.08.

3-Benzyl-3a-butyl-1-phenyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7ey**).

This compound was prepared as colourless crystals, 421 mg (95%), mp 152-163 °C (cyclohexane); ir: ν 3356, 3214, 3064, 2959, 2928, 2871, 1690, 1617, 1601, 1496, 1440, 1411, 1364, 1157, 1125, 1072, 1042, 1025, 954, 919, 865, 831, 756, 731, 697, 670, 655, 616, 600, 551, 507, 491 cm^{-1}; positive-ion APCI-ms:

m/z 442 $[M+H]^+$, 424 $[M+H-H_2O]^+$ (100%), 398 $[M+H-NH_2CO]^{+\cdot}$, 323 $[M+H-C_6H_5NCO]^+$; positive-ion APCI-ms/ms of *m/z* 442: *m/z* 323 $[M+H-C_6H_5NCO]^+$ (100%), 233 $[C_6H_4NHCOC(butyl)(NH)CH(OH)]^+$, 215 $[233-H_2O]^+$, 184 $[C_6H_5CH_2NH_2C_6H_5]^+$, 146 $[C_6H_4NHCOCHCH_2]^+$; negative-ion APCI-ms: *m/z* 440 $[M-H]^-$, 422 $[M-H-H_2O]^-$, 411 $[M-HCO]^-$, 366 [M-H-H_2O-butene]$^-$, 321 $[M-H-C_6H_5NCO]^-$, 216 $[C_6H_4NHCOC(butyl)CO]^-$, 188 $[216-CO]^-$; negative-ion APCI-ms/ms of *m/z* 440: *m/z* 321 $[M-H-C_6H_5NCO]^-$ (100%), 303 $[M-H-C_6H_5NCO-H_2O]^-$, 216 $[C_6H_4NHCOC(butyl)CO]^-$.

Anal. Calcd. for $C_{27}H_{27}N_3O_3$: C, 73.45; H, 6.16; N, 9.52. Found: C, 73.21; H, 6.32; N, 9.48.

1,3-Dibutyl-3a-phenyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7fx**).

This compound was prepared as colourless crystals, 318 mg (78%), mp 131-138 °C (ethyl acetate); ir: ν 3377, 3202, 3145, 3083, 2959, 2931, 2873, 1690, 1679, 1617, 1601, 1498, 1462, 1448, 1413, 1363, 1313, 1211, 1135, 1094, 1058, 1046, 977, 936, 865, 844, 770, 749, 698, 675, 626, 599, 558, 540 cm^{-1}; positive-ion APCI-ms: *m/z* 408 $[M+H]^+$ (100%), 390 $[M+H-H_2O]^+$, 364 $[M+H-NH_2CO]^+$, 309 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$; positive-ion APCI-ms/ms of *m/z* 408: *m/z* 309 $[M+H-CH_3CH_2CH_2CH_2NCO]^+$ (100%), 236 $[M+H-CH_3CH_2CH_2CH_2NCO-CH_3CH_2CH_2CH_2NH_2]^+$, 208 $[236-CO]^+$; negative-ion APCI-ms: *m/z* 406 $[M-H]^-$ (100%), 377 $[M-H-HCO]^-$, 307 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$; negative-ion APCI-ms/ms of *m/z* 406: *m/z* 388 $[M-H-H_2O]^-$, 362 $[M-H-NH_2CO]^-$, 307 $[M-H-CH_3CH_2CH_2CH_2NCO]^-$ (100%), 289 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$, 264 $[M-H-CH_3CH_2CH_2CH_2NCO-NHCO]^-$, 250 $[M-H-CH_3CH_2CH_2CH_2NCO-butyl]^-$, 230 $[M-H-CH_3CH_2CH_2CH_2NCO-C_6H_5]^-$.

Anal. Calcd. for $C_{24}H_{29}N_3O_3$: C, 70.74; H, 7.17; N, 10.31. Found: C, 70.61; H, 7.31; N, 10.45.

3-Butyl-1,3a-diphenyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7fy**).

This compound was prepared as colourless crystals, 239 mg (56%), mp 147-155 °C (ethyl acetate); ir: ν 3404, 3255, 3201, 3144, 3067, 2981, 2956, 2932, 2872, 1690, 1619, 1602, 1496, 1450, 1406, 1370, 1220, 1140, 1106, 1084, 1048, 1029, 985, 951, 902, 867, 831, 803, 767, 751, 697, 673, 655, 598, 576, 519 cm^{-1}; positive-ion APCI-ms: *m/z* 428 $[M+H]^+$ (100%), 410 $[M+H-H_2O]^+$, 384 $[M+H-NH_2CO]^{+\cdot}$, 309 $[M+H-C_6H_5NCO]^+$, 236 $[M+H-C_6H_5NCO-CH_3CH_2CH_2CH_2NH_2]^+$, 208 $[236-CO]^+$; positive-ion APCI-ms/ms of *m/z* 428: *m/z* 309 $[M+H-C_6H_5NCO]^+$ (100%), 291 $[M+H-C_6H_5NCO-H_2O]^+$, 236 $[M+H-C_6H_5NCO-CH_3CH_2CH_2CH_2NH_2]^+$, 208 $[236-CO]^+$; negative-ion APCI-ms: *m/z* 426 $[M-H]^-$ (100%), 397 $[M-H-HCO]^-$, 307 $[M-H-C_6H_5NCO]^-$; negative-ion APCI-ms/ms of *m/z* 426: *m/z* 307 $[M-H-C_6H_5NCO]^-$ (100%), 264 $[M-H-C_6H_5NCO-NHCO]^-$, 250 $[M-H-C_6H_5NCO-butyl]^-$.

Anal. Calcd. for $C_{26}H_{25}N_3O_3$: C, 73.05; H, 5.89; N, 9.83. Found: C, 73.21; H, 5.98; N, 9.72.

3-Benzyl-1-butyl-3a-phenyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7gx**).

This compound was prepared as colourless crystals, 411 mg (93%), mp 125-130 °C (benzene-cyclohexane); ir: ν 3402, 3239, 3207, 3090, 3063, 2958, 2928, 2871, 1698, 1617, 1600, 1494, 1448, 1406, 1372, 1361, 1329, 1241, 1125, 1093, 1059, 1046, 1030, 974, 938, 898, 759, 750, 697, 673, 602, 559, 513 cm^{-1}; positive-ion APCI-ms: *m/z* 442 $[M+H]^+$ (100%), 424 $[M+H-H_2O]^+$, 398 $[M+H-NH_2CO]^+$; positive-ion APCI-ms/ms of *m/z* 442: *m/z* 424 $[M+H-H_2O]^+$, 364 $[M+H-C_6H_6]^+$, 343 (100%) $[M+H-CH_3CH_2CH_2CH_2NCO]^+$, 334 $[M+H-C_6H_6-H_2CO]^+$, 265 $[M+H-CH_3CH_2CH_2CH_2NCO-C_6H_6]^+$, 164 $[C_6H_5CH_2NH_2CH_2CH_2-CH_2CH_3]^+$; negative-ion APCI-ms: *m/z* 440 $[M-H]^-$ (100%), 411 $[M-H-HCO]^-$; negative-ion APCI-ms/ms of *m/z* 440: *m/z* 422 $[M-H-H_2O]^-$, 396 $[M-H-NH_2CO]^-$, 341 $[M-H-CH_3CH_2CH_2-CH_2NCO]^-$ (100%), 323 $[M-H-CH_3CH_2CH_2CH_2NCO-H_2O]^-$, 298 $[M-H-CH_3CH_2CH_2CH_2NCO-NHCO]^-$, 263 $[M-H-CH_3CH_2CH_2CH_2NCO-C_6H_6]^-$, 250 $[M-H-CH_3CH_2CH_2CH_2NCO-C_6H_5CH_2]^-$, 207 $[250-NHCO]^-$.

Anal. Calcd. for $C_{27}H_{27}N_3O_3$: C, 73.45; H, 6.16; N, 9.52. Found: C, 73.24; H, 6.31; N, 9.46.

3-Benzyl-1,3a-diphenyl-9b-hydroxy-3,3a,5,9b-tetrahydro-1*H*-imidazo[4,5-*c*]quinoline-2,4-dione (**7gy**).

This compound was prepared as colourless crystals, 279 mg (60%), mp 140-147 °C (hexane-ethyl acetate); ir: ν 3353, 3194, 3062, 3034, 2992, 2925, 2877, 1700, 1675, 1600, 1497, 1439, 1403, 1349, 1310, 1288, 1157, 1139, 1127, 1088, 1062, 1050, 1031, 972, 879, 828, 753, 729, 695, 684, 612, 519 cm^{-1}; positive-ion APCI-ms: *m/z* 462 $[M+H]^+$ (100%), 444 $[M+H-H_2O]^+$, 418 $[M+H-NH_2CO]^+$, 343 $[M+H-C_6H_5NCO]^+$; positive-ion APCI-ms/ms of *m/z* 462: *m/z* 343 $[M+H-C_6H_5NCO]^+$ (100%), 253 $[C_6H_4NHCOC-(C_6H_5)(NH)CHOH]^+$, 236 $[253-NH_3]^+$, 208 $[253-NH_3-CO]^+$, 184 $[C_6H_5CH_2NH_2C_6H_5]^+$; negative-ion APCI-ms: *m/z* 460 $[M-H]^-$ (100%), 431 $[M-H-HCO]^-$, 341 $[M-H-C_6H_5NCO]^-$; negative-ion APCI-ms/ms of *m/z* 460: *m/z* 341 $[M-H-C_6H_5NCO]^-$ (100%), 323 $[M-H-C_6H_5NCO-H_2O]^-$, 250 $[M-H-C_6H_5NCO-C_6H_5CH_2]^-$, 207 $[M-H-C_6H_5NCO-C_6H_5CH_2NHCO]^-$.

Anal. Calcd. for $C_{29}H_{23}N_3O_3$: C, 75.47; H, 5.02; N, 9.10. Found: C, 75.31; H, 5.24; N, 9.15.

Preparation of Ethyl 3-Butyl-2,4-dioxo-1*H*,3*H*-quinolin-3-ylcarbamate (**8**).

Ethyl chloroformate (0.115 ml, 1.2 mmoles) was added to the cooled (0 °C) and stirred solution of **7a** (0.232 g, 1 mmol) in pyridine (2 ml). After 3 h at rt, the solution was evaporated *in vacuo* to 0.5 ml and diluted with water (10 ml). The precipitated pure product was collected by filtration with suction. Yield 0.238 g (78%) of colourless crystals, mp 163-164 °C; ir: ν 3360, 3243, 3205, 2990, 2959, 2933, 2872, 1715, 1674, 1612, 1526, 1485, 1376, 1274, 1158, 1063, 800, 781, 766, 666 cm^{-1}; positive-ion APCI-ms and ms/ms of *m/z* 305 are the same: *m/z* 305 $[M+H]^+$ (100% for ms), 259 $[M+H-CH_3CH_2OH]^+$, 233 $[C_6H_4-NHCOC(butyl)(NH_3)CO]^+$, 215 $[M+H-CH_3CH_2OH-NH_2CO]^{+\cdot}$ (100% for ms/ms), 188 $[M+H-CH_3CH_2OH-NH_2CO-HCN]^+$; negative-ion APCI-ms: *m/z* 303 $[M-H]^-$, 257 $[M-H-CH_3CH_2-OH]^-$ (100%), 231 $[C_6H_4NHCOC(butyl)(NH)CO]^-$, 213 $[M-H-CH_3CH_2OH-NH_2CO]^-$, 200 $[M-H-CH_3CH_2OH-butyl]^-$, 186 $[M-H-CH_3CH_2OH-NH_2CO-HCN]^-$; negative-ion APCI-ms of *m/z* 303: *m/z* 257 $[M-H-CH_3CH_2OH]^-$ (100%), 213 $[M-H-CH_3CH_2OH-NH_2CO]^-$, 200 $[M-H-CH_3CH_2OH-butyl]^-$.

Anal. Calcd. for $C_{16}H_{20}N_2O_4$: C, 63.14; H, 6.62; N, 9.20. Found: C, 63.01; H, 6.88; N, 9.07.

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