Synthesis and Biological Evaluation of Structural Variants of Carbazoquinocin C

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Some new structural variants of the alkaloid carbazoquinocin C were synthesized in a few steps with good to excellent yields. The key step comprises a cyclisation reaction of appropriate 2-vinylindoles with oxalyl chloride. The carbazole-3,4-quinones are able to trap oxygen-centred radicals. In some biological/biochemical assays some of these compounds exhibit extraordinary results including inhibition of cyclooxygenase-1 and 5-lipoxygenase in the μM-range. Moreover some of the carbazoquinocin C-variants inhibit significant oxidative damage of cellular DNA in nM-range.

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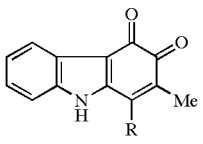
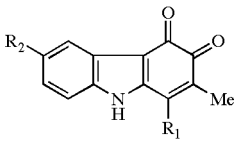
Introduction.

Dioxocarbazole alkaloids are a relatively new group of natural compounds with a promising pharmacological profile [1,2]. From the series carbazoquinocin C (**55**) and structural variants **53-60** isolated from different *Streptomyces* spp. belong to a new class of antioxidative agents with interesting biological effects [3-6]. They exhibit strong inhibition of lipid peroxidation induced by oxygen-derived free radicals [7]. These compounds possess an interesting potential for the development of new drugs for therapy of myocardial and cerebral ischemia, arteriosclerosis, inflammation, rheumatism, senility, autoimmune diseases, cancer and neurogenerative diseases [8]. Therefore these novel carbazole alkaloids attracted considerable interest among synthetic organic chemists. Ogasawara reported the first synthesis of the carbazole-3,4-quinones carbazoquinocin A and D [9]. An allene mediated ring closure reaction was used by Hibino *et al*. to produce carbazoquinocins [10]. Several carbazoquinocins were produced by metal-catalyzed (iron and palladium (II)) oxidative cyclisation strategy by Knölker *et al* [11-14]. In our laboratory we have established a new method to synthesize carbazoquinocin C-variants which has been published in a preliminary form [15,16].



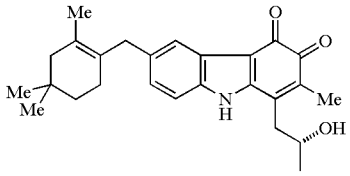
Carbazoquinocin A-F

53: R = $(CH_2)_2CHMeCH_2Me$
54: R = $(CH_2)_4CHMe_2$
55: R = $(CH_2)_6Me$
56: R = $(CH_2)_4CHMeCH_2Me$
57: R = $(CH_2)_5CHMe_2$
58: R = $(CH_2)_6CHMe_2$



Carquinostatin A 59:

R_1= $CH_2CH(OH)CH_3$
R_2= $CH_2CH=C(CH_3)_2$



60: Lavanduquinocin

The key step comprises a polar cyclisation reaction of an appropriately functionalised 2-vinylindole with oxalyl chloride as the resulting *ortho*-diketone synthon. By variation of the substituents at the 1 and 2 positions of the 2-vinylindole building block in the naturally occurring compound (**55**), several carbazoquinocin C-variants were available (Scheme 1). In the present paper further synthetic developments are presented in full form and, first of all, a preparative broader application to a variety of new oxocarbazole-3,4-diones will be demonstrated. Moreover, the results of the antioxidative activity are described by several biochemical assays. Additionally an oxygen-radical scavenger effect by ESR method and a bioreduction reaction by NMR analysis are exemplarily discussed for some of the products.

Results and Discussion.

Synthetic Aspects.

On the basis of our established new synthesis of the natural antioxidative compound carbazoquinocin C (**55**) a great variety of congeners with different groups at the 1- and 2-positions of the carbazole framework were produced (Scheme 1). The introduction of several aliphatic, aromatic and heteroaromatic groups leads to a broad spectrum of products for prospective studies of structure activity relationships in the biology of antioxidants. The respective 2-vinylindoles **1-26** were in all cases readily available by elimination reactions of the appropriate indolyl-carbinols as precursors. Direct elimination and hydrolysis of the respective *N*-phenylsulfonylindole carbinols with ethanolic aqueous NaOH of the compounds resulted in the formation

of aliphatic, aromatic and heteroaromatic 2-vinylindoles (**1**), **13-26**. In the case of aliphatic 2-vinylindoles **2-12** other conditions were necessary. Thus treatment of the respective aliphatic indolyl-carbinols with trifluoro-acetic acid/triethyl amine mixture in chloroform provided the isomeric *E*/*Z* 2-vinylindoles **2-12**. Then the *N*-sulfonyl protection group was removed in NaOH-ethanol-mixture. The starting indolyl-carbinols were synthesized from *N*-phenylsulfonylindole with aliphatic, aromatic and heteroaromatic ketones *via* regioselective 2-lithiation of *N*-phenylsulfonylindole with LDA in THF at low temperature (-20 °C) under an argon atmosphere as previously described [15]. For the decisive cyclization procedure the 2-vinylindoles were transformed to indol-3-glyoxyl-chlorides with oxalyl chloride. These compounds were further processed without purification. The $AlCl_3$ catalyzed cyclization reactions produce the carbazoquinocin C variants in 43-64% yields. The reaction was optimized as a one pot procedure transforming **1-26** directly to the carbazoles **27-52**. All carbazoquinocin C-variants **27-52** were characterized by ^{1}H-NMR, ^{13}C-NMR, UV-Vis, MS and elemental analysis. For experimental details of products **27-52** see the experimental part [15]. The synthetic details of oxocarbazoles, which gave the interesting biological results **61**-**64**, are described in our preliminary report [15].

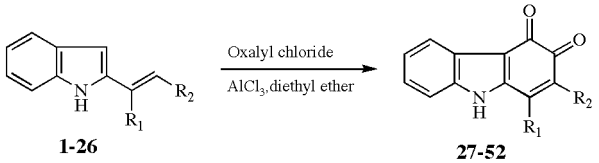
Biological/Biochemical Evaluation.

Using a biochemical assay (malone dialdehyde-method) it was shown that from the carbazole-3,4-quinones of the series **27-52** and **61**-**64** some canditates inhibited the cyclooxygenase 1/thromboxane synthase path of the arachidonic acid cascade in the μM range (Table 1) [17-19]. In addition the cyclooxygenase I and 5-lipoxygenase inhibitions were studied by a special HPLC-method [20]. These results were compared with the antiphlogistic industrial drugs *carprofene* and *indometacin* (Table 1). In a biological assay it was shown, that the carbazoquinocin C-variant (**63**) inhibits significant oxidative damage of cellular DNA. This assay was performed by the alkaline elution assay (see Table 1) [21,22]. From the overall results it was found that the tested carbazoquinocin C-variants represented a new class of antioxidative compounds as α-tocopherol-mimetics [23].

Molecular Aspects of the Biological Effects by Spectroscopic Methods.

From the given series the carbazoquinocin C-variants (**62**), (**63**) and (**64**) were tested in a cellular system for their oxygen-radical scavenging activity by electron spin resonance spectroscopy (ESR). These compounds trap formed superoxide radical anions *in situ*. In this test system the

Scheme 1

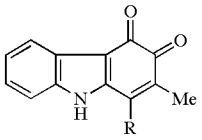


1-26 **27-52**

1	R_1= C_2H_5	R_2= Me	**27**	R_1= C_2H_5	R_2= Me	47 %
2	R_1= C_3H_7	R_2= Me	**28**	R_1= C_3H_7	R_2= Me	55 %
3	R_1= *n*-C_4H_9	R_2= Me	**29**	R_1= *n*-C_4H_9	R_2= Me	57 %
4	R_1= *n*-C_5H_{11}	R_2= Me	**30**	R_1= *n*-C_5H_{11}	R_2= Me	55 %
5	R_1= *n*-C_6H_{13}	R_2= Me	**31**	R_1= *n*-C_6H_{13}	R_2= Me	57 %
6	R_1= *n*-C_9H_{19}	R_2= Me	**32**	R_1= *n*-C_9H_{13}	R_2= Me	54 %
7	R_1= C_2H_5	R_2= C_2H_5	**33**	R_1= C_2H_5	R_2= C_2H_5	58 %
8	R_1= C_2H_5	R_2= C_3H_7	**34**	R_1= C_2H_5	R_2= C_3H_7	55 %
9	R_1= C_2H_5	R_2= *n*-C_4H_9	**35**	R_1= C_2H_5	R_2= n-C_4H_9	60 %
10	R_1= C_2H_5	R_2= *n*-C_5H_{11}	**36**	R_1= C_2H_5	R_2= n-C_5H_{11}	54 %
11	R_1= C_2H_5	R_2= *n*-C_6H_{13}	**37**	R_1= C_2H_5	R_2= n-C_6H_{13}	54 %
12	R_1= C_2H_5	R_2= *n*-C_8H_{17}	**38**	R_1= C_2H_5	R_2= n-C_8H_{17}	51 %
13	R_1= *p*-F-Ph	R_2= H	**39**	R_1= *p*-F-Ph	R_2= H	54 %
14	R_1= *p*-OMe-Ph	R_2= H	**40**	R_1= *p*-OMe-Ph	R_2= H	59 %
15	R_1= 3,4-di-OMe-Ph	R_2= H	**41**	R_1= 3,4-di-OMe-Ph	R_2= H	58 %
16	R_1= Ph	R_2= H	**42**	R_1= Ph	R_2= H	59 %
17	R_1= Ph	R_2= Me	**43**	R_1= Ph	R_2= Me	56 %
18	R_1= *p*-OMe-Ph	R_2= Me	**44**	R_1= *p*-OMe-Ph	R_2= Me	61 %
19	R_1= *m*-NO_2-Ph	R_2= Me	**45**	R_1= *m*-NO_2-Ph	R_2= Me	53 %
20	R_1= *p*-Cl-Ph	R_2= Me	**46**	R_1= *p*-Cl-Ph	R_2= Me	62 %
21	R_1= 1-biphenyl	R_2= Me	**47**	R_1= 1-biphenyl	R_2= Me	60 %
22	R_1= 3,4-di-OMe-Ph	R_2= Me	**48**	R_1= 3,4-di-OMe-Ph	R_2= Me	57 %
23	R_1= 1-naphthyl	R_2= Me	**49**	R_1= 1-naphthyl	R_2= Me	59 %
24	R_1= 3-indolyl	R_2= Me	**50**	R_1= 3-indolyl	R_2= Me	58 %
25	R_1= 3-indolyl	R_2= H	**51**	R_1= 3-indolyl	R_2= H	43 %
26	R_1= Ph	R_2= C_2H_5	**52**	R_1= Ph	R_2= C_2H_5	64 %

Table 1

IC_{50} inhibition values of cyclooxygenase 1 and 5-lipoxygenase by oxocarbazoles and by the antiphlogistic drugs carprofene and indometacin and inhibition of oxidative DNA damage. Only the results of the promising canditates are given. MDA: malone dialdehyde.



Compound	R	COX 1-inhibition IC_{50} [μM], MDA-method	COX 1-inhibition IC50 [μM], HPLC-method
55	*n*-C_7H_{15}	›10	—-
61	*p*-Br-Ph	10	—-
62	*p*-F-Ph	7.89	—-
63	*p*-Me-Ph	0.45	10
64	2-thienyl	0.47	1.1
Indometacin		—-	0.006
Carprofene		—-	3.1

Compound	R	5-LOX-inhibition IC50 [μM], HPLC-method	Inhibition of oxidative DNA damage; AS52 cells damage induced with a photosensibilisator
63	*p*-Me-Ph	1.1	3-10 nM
64	*2*-thienyl	0.7	—-

superoxide radical anions were produced by polymorphic nucleus leukocytes from bovine serum. As a spin trap reagent 5-diethoxy-phosphoryl-5-methyl-1-pyrroline-*N*-oxide was used. In this cellular system the compound (**64**) traps superoxide radical anions more effectively than nordihydroguaretic acid. ^{1}H- and ^{13}C-NMR- and UV-VIS-spectroscopic measurements of type (**55**) in the presence of glutathione as a reductive bioorganic reagent revealed *ortho*-quinone reduction to an *ortho*-hydroquinone-system. Recently carbazole dione reduction chemistry was also studied by electrochemical and quantum chemical methods [24]. In summary, for biological redox-activities of quinones in cellular systems the bioreduction of quinones by reduction reagents, for example glutathione, seems to be very important. Thus these formal phenolic species are probably the direct agents acting as radical scavengers in biological materials.

Conclusion.

The described method allows the flexible synthesis of a variety of new functionalized carbazoquinocin-3,4-diones in a short *in situ* reaction. Moreover some of the carbazoquinocin C-variants inhibit cyclooxygenase I and 5-lipoxygenase in the μM-range. The carbazoquinocin C-variant (**63**) inhibits significant oxidative damage of cellular DNA in the nM-range. The ESR measurements show that the oxocarbazoles trap superoxide radical anions in the μM-range. ^{1}H- and ^{13}C-NMR- and UV-VIS-spectroscopic measurements of some of the oxocarbazoles with glutathione as a reductive bioorganic reagent reveal *ortho*-quinone reduction to an *ortho*-hydroquinone-system. These phenolic compounds are the direct antioxidative precursors of radical scavengers in biological/-biological systems.

EXPERIMENTAL

General Details.

^{1}H and ^{13}C NMR spectra were recorded at room temperature using Bruker AC 300 and 400 spectrometers and Me_4Si as internal reference and *J* values are given in Hz. The FD mass spectra were measured with a Varian CH 7a spectrometer. Ionisation modes are indicated in parentheses. Elemental analyses were performed using a Carlo Erba Strumentazione 1106 apparatus. Mps were measured with an Electrothermal 8200 instrument. Flash column chromatography was performed on Merck 60 silica gel (particle size: 0.040-0.063 mm). An Hitachi L-4000 UV-detector was used at λ = 254 nm. A Bruker EPR EMX 300 spectrometer was used to estimate oxygen-scavenging activity. The light petroleum used boiled in the range 40-60 °C. All reactions were performed in highly pure, anhydrous solvents under argon atmospheres. The yields given refer to analytically pure compounds. The synthesis of **61**-**64** with physical data was already described in our preliminary publication [15]

General Procedure for the Preparation of Carbazole-3,4-quinones.

To a three necked 100 ml flask containing the respective 2-vinylindole (1 g, 3.33 mmol) in anhydrous Et_2O (25 ml) a solution of oxalyl chloride (0.37 ml, 4.4 mmol) in anhydrous Et_2O (0.5 ml) at 0 °C under argon atmosphere was added dropwise over a period of 5 min. The mixture was stirred for an

additional 30 min, during which time a fine brown suspension had formed. After this reaction time $AlCl_3$ (2.21 g, 16.6 mmol) was added in small portions. The colour of the mixture changed to violet and the formed dark suspension was collected. Then the mixture was poured into crushed ice (400 ml). The aqueous layer was extracted with several volumes of ethyl acetate and the organic extract was washed with brine (100 ml), saturated aqueous $NaHCO_3$ (100 ml) and brine (100 ml), dried with Na_2SO_4, and concentrated *in vacuo* to give 52-61% yields. Crystallization from MeOH gave the analytically dark green pure samples.

1-Ethyl-2-methyl-4,9-dihydro-3*H*-3,4-carbazoldione (27).

This compound was obtained from 2-[(*E*)-1-ethyl-1-propenyl]-indole (**1**) 620 mg (3.33 mmol) as starting educt. Yield 0.37g (47 %), mp 204 °C (from ethanol); $C_{15}H_{13}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ1.16 (t, *J*=7.1 Hz, 3H, CH_3); 1.86 (s, 3H, CH_3); 2.57 (m, 2H, CH_2); 7.24 (m, 2H, C_{6-7}); 7.49 (m, 1H, C_8); 7.83 (m, 1H, C_5); 12.41 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 11.3 (CH_3); 13.3 (CH_3); 21.6 (CH_2); 111.4 (Cq); 113.7 (CH); 120.6 (CH); 124.2 (CH); 124.4 (CH); 126.0 (Cq); 133.0 (Cq); 137.4 (Cq); 143.7 (Cq); 145.7 (Cq); 173.0 (C=O); 183.8 (C=O); ms: *m/z* (FD) 239.7 (M^+, 100%); uv (ethanol): λ max 400 nm (ε 8373), λ max 264 nm (ε 47703), λ max 230 nm (ε 56794).

2-Methyl-1-propyl-4,9-dihydro-3*H*-3,4-carbazoldione (**28**).

This compound was obtained from 2-[(*E*)-1-propyl-1-propenyl]-indole (**2**) 660 mg (3.33 mmol) as starting educt. Yield 0.46g (55 %), mp 226 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.02 (t, *J*=7.2 Hz, 3H, CH_3); 1.59 (m, 2H, CH_2); 1.88 (s, 3H, CH_3); 2.63 (t, *J*=7.9 Hz, 2H, CH_2); 7.23 (m, 2H, C_{6-7}); 7.50 (m, 1H, C_8); 7.85 (m, 1H, C_5); 12.34 (s, 1H, NH) ; ^{13}C nmr (dimethylsulfoxide-d_6): δ 11.8 (CH_3); 14.1 (CH_3); 22.1 (CH_2); 30.1 (CH_2); 111.4 (Cq); 113.7 (CH); 120.6 (CH); 124.3 (CH); 124.5 CH); 126.0 (Cq); 133.7 (Cq); 137.4 (Cq); 142.2 (Cq); 146.0 (Cq); 173.0 (C=O); 183.8 (C=O); ms: *m/z* (FD) 253.7 (M^+, 100%); uv (ethanol): λ max 402 nm (ε 2076), λ max 265 nm (ε 15190), λ max 228 nm (ε 29359).

Anal. Calcd. for $C_{16}H_{15}NO_2$: C, 75.87; H, 5.97; N, 5.53. Found: C, 75.03; H, 5.97; N, 5.35.

1-*n*-Butyl-2-methyl-4,9-dihydro-3*H*-3,4-carbazoldione (**29**).

This compound was obtained from 2-[(*E*)-1-butyl-1-propenyl]-indole (**3**) 710 mg (3.33 mmol) as starting educt. Yield 0.51g (57%), mp 243 °C (from methanol); $C_{17}H_{17}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.92 (t, *J*=7.0 Hz, 3H, CH_3); 1.39-1.58 (m, 4H, CH_2); 1.88 (s, 3H, CH_3); 2.65 (t, *J*=7.5 Hz, 2H, CH_2); 7.23 (m, 2H, C_{6-7}); 7.51 (m, 1H, C_8); 7.84 (m, 1H, C_5); 12.42 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 11.8 (CH_3); 14.2 (CH_3); 22.5 (CH_2); 28.2 (CH_2); 31.0 (CH_2); 111.4 (Cq); 113.7 (CH); 120.6 (CH); 124.3 (CH); 124.47 CH); 126.0 (Cq); 133.4 (Cq); 137.4 (Cq); 142.5 (Cq); 146.0 (Cq); 173.1 (C=O); 183.8 (C=O); ms: *m/z* (FD) 267.7 (M^+, 100%); uv (ethanol): λ max 404 nm (ε 3583), λ max 346 nm (ε 3021 nm), λ max 265 nm (ε 25267), λ max 228 nm (ε 29359).

2-Methyl-1-*n*-pentyl-4,9-dihydro-3*H*-3,4-carbazoldione (**30**).

This compound was obtained from 2-[(*E*)-1-pentyl-1-propenyl]-indole (**4**) 760 mg (3.33 mmol) as starting educt. Yield 0.51g (55%), mp 224 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.87 (t, *J*=7.2 Hz, 3H, CH_3); 1.29-1.58 (m, 6H, CH_2); 1.89 (s, 3H, CH_3); 2.65 (t, *J*=7.0 Hz, 2H, CH_2); 7.23 (m, 2H, C_{6-7}); 7.51 (m, 1H, C_8); 7.85 (m, 1H, C_5); 12.35 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 11.7 (CH_3); 14.2 (CH_3); 22.4 (CH_2); 28.3 (CH_2); 28.5 (CH_2); 31.5 (CH_2); 111.4 (Cq); 113.7 (CH); 120.6 (CH); 124.3 (CH); 124.50 CH); 126.0 (Cq); 133.4 (Cq); 137.4 (Cq); 142.5 (Cq); 146.0 (Cq); 173.1 (C=O); 183.8 (C=O); ms: *m/z* (FD) 281.7 (M^+, 100%); uv (ethanol): λ max 401 nm (ε 5618), λ max 265 nm (ε 34607), λ max 229 (ε 42079).

Anal. Calcd. for $C_{18}H_{19}NO_2$: C, 76.84; H, 6.81; N, 4.98. Found: C, 76.76; H, 6.87; N, 4.93.

1-*n*-Hexyl-2-methyl-4,9-dihydro-3*H*-3,4-carbazoldione (**31**).

This compound was obtained from 2-[(*E*)-1-hexyl-1-propenyl]-indole (**5**) 800 mg (3.33 mmol) as starting educt. Yield 0.56g (57%), mp 205 °C (from methanol); $C_{19}H_{21}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.88 (m, 3H, CH_3); 1.21-1.39 (m, 4H, CH_2); 1.42-1.56 (m, 4H, CH_2); 1.89 (s, 3H, CH_3); 2.47 (m, 2H, CH_2); 7.24 (m, 2H, C_{6-7}); 7.51 (m, 1H, C_8); 7.85 (m, 1H, C_5); 12.38 (s, 1H, NH) ; ^{13}C nmr (dimethylsulfoxide-d_6): δ 11.8 (CH_3); 14.3 (CH_3); 22.4 (CH_2); 28.4 (CH_2); 28.8 (CH_2); 29.0 (CH_2); 31.5 (CH_2); 111.4 (Cq); 113.69 (CH); 120.6 (CH); 124.3 (CH); 124.5 (CH); 126.0 (Cq); 133.4 (Cq); 137.4 (Cq); 142.5 (Cq); 145.9 (Cq); 173.1 (C=O); 183.8 (C=O); ms: *m/z* (FD) 295.7 (M^+, 100%); uv (ethanol): λ max 400 nm (ε 3746), λ max 265 nm (ε 25487), λ max 229 nm (ε 42079).

2-Methyl-1-*n*-nonyl-4,9-dihydro-3*H*-3,4-carbazoldione (**32**).

This compound was obtained from 2-[(*E*)-1-nonyl-1-propenyl]-indole (**6**) 940 mg (3.33 mmol) as starting educt. Yield 0.61g (54%), mp 221 °C (from methanol); $C_{22}H_{27}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.83 (m, 3H, CH_3); 1.12-1.56 (m, 14H, CH_2); 1.88 (s, 3H, CH_3); 2.49 (m, 2H, CH_2); 7.22 (m, 2H, C_{6-7}); 7.51 (m, 1H, C_8); 7.86 (m, 1H, C_5); 12.36 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 11.8 (CH_3); 14.2 (CH_3); 22.4 (2xCH_2); 28.4 (CH_2); 28.8 (CH_2); 29.0 (CH_2); 29.3 (2xCH_2); 31.6 (CH_2); 111.4 (Cq); 113.7 (CH); 120.6 (CH); 124.3 (CH); 124.5 (CH); 126.0 (Cq); 133.4 (Cq); 137.4 (Cq); 142.5 (Cq); 145.9 (Cq); 173.1 (C=O); 183.8 (C=O); ms: *m/z* (FD) 337.9 (M^+, 100%); uv (ethanol): λ max 400 nm (ε 5960), λ max 265 nm (ε 35657), λ max 229 nm (ε 40236).

1,2 Diethyl-4,9-dihydro-3*H*-3,4-carbazoldione (**33**).

This compound was obtained from 2-[(*E*)-1-ethyl-1-butenyl]-indole (**7**) 660 mg (3.33 mmol) as starting educt. Yield 0.49g (58%), mp 225 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.99 (t, *J*=7.6 Hz, 3H, CH_3); 1.22 (t, *J*=7.2 Hz, 3H, CH_3); 2.36 (dd, *J*=7.6 Hz, *J*=7.6 Hz, 2H, CH_2); 2.66 (m, 2H, CH_2); 7.23 (m, 2H, C_{6-7}); 7.50 (m, 1H, C_8); 7.85 (m, 1H, C_5); 12.41 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.4 (CH_3); 14.4 (CH_3); 19.1 (CH_2); 21.4 (CH_2); 111.6 (Cq); 113.7 (CH); 120.6 (CH); 124.3 (CH); 124.5 (CH); 125.93 (Cq); 137.5 (Cq); 138.5 (Cq); 143.6 (Cq); 145.6 (Cq); 173.0 (C=O); 183.6 (C=O); ms: *m/z* (FD) 253.7 (M^+, 100%); uv (ethanol): λ max 401 nm (ε 2354), λ max 265 nm (ε 17241), λ max 229 nm (ε 18633).

Anal. Calcd. for $C_{16}H_{15}NO_2$: C, 75.87; H, 5.97; N, 5.53. Found: C, 74.81; H, 6.14; N, 5.34.

1-Ethyl-2-*n*-propyl-4,9-dihydro-3*H*-3,4-carbazoldione (**34**).

This compound was obtained from 2-[(*E*)-1-ethyl-1-pentenyl]-indole (**8**) 710 mg (3.33 mmol) as starting educt. Yield 0.49g (55%), mp 215 °C (from methanol); $C_{17}H_{17}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.91 (t, *J*=7.6 Hz, 3H, CH_3); 1.21 (t,

J=7.7 Hz, 3H, CH_3); 1.37 (m, 2H, CH_2); 2.32 (t, *J*=7.9, 2H, CH_2); 2.65 (m, 2H, CH_2); 7.22 (m, 2H, C_{6-7}); 7.49 (m, 1H, C_8); 7.84 (m, 1H, C_5); 12.41 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.4 (CH_3); 14.5 (CH_3); 21.5 (CH_2); 22.8 (CH_2); 27.8 (CH_2); 111.6 (Cq); 113.7 (CH); 120.6 (CH); 124.27 (CH); 124.5 CH); 125.9 (Cq); 137.1 (Cq); 137.5 (Cq); 144.0 (Cq); 145.5 (Cq); 172.9 (C=O); 183.8 (C=O); ms: *m/z* (FD) 267.7 (M^+, 100%); uv (ethanol): λ max 402 nm (ε 3342), λ max 265 nm (ε 20321), λ max 229 nm (ε 24599).

2-*n*-Butyl-1-ethyl-4,9-dihydro-3*H*-3,4-carbazoldione (**35**).

This compound was obtained from 2-[(*E/Z*)-1-ethyl-1-hexenyl]-indole (**9**) 760 mg (3.33 mmol) as starting educt. Yield 0.56g (60%), mp 213 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.87 (m, 3H, CH_3); 1.21 (t, *J*=7.5 Hz, 3H, CH_3); 1.26-1.48 (m, 4H, CH_2); 2.33 (m, 2H, CH_2); 2.65 (m, 2H, CH_2); 7.22 (m, 2H, C_{6-7}); 7.49 (m, 1H, C_8); 7.83 (m, 1H, C_5); 12.39 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.1 (CH_3); 14.4 (CH_3); 21.5 (CH_2); 22.7 (CH_2); 25.6 (CH_2); 31.7 (CH_2); 111.6 (Cq); 113.7 (CH); 120.6 (CH); 124.26 (CH); 124.5 (CH); 126.0 (Cq); 137.3 (Cq); 137.5 (Cq); 143.8 (Cq); 145.6 (Cq); 172.9 (C=O); 183.7 (C=O); ms: *m/z* (FD) 281.7 (M^+, 100%); uv (ethanol): λ max 402 nm (ε 3708), λ max 265 nm (ε 21236), λ max 229 nm (ε 25618).

Anal. Calcd. for $C_{18}H_{19}NO_2$: C, 76.89; H, 6.81; N, 4.98. Found: C, 74.00; H, 6.71; N, 4.95.

1-Ethyl-2-*n*-pentyl-4,9-dihydro-3*H*-3,4-carbazoldione (**35**).

This compound was obtained from 2-[(*E/Z*)-1-ethyl-1-heptenyl]-indole (**10**) 800 mg (3.33 mmol) as starting educt. Yield 0.53g (54%), mp 205 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.84 (m, 3H, CH_3); 1.18-1.29 (m, 9H, CH_2-CH_3); 2.31 (m, 2H, CH_2); 2.65 (m, 2H, CH_2); 7.22 (m, 2H, C_{6-7}); 7.49 (m, 1H, C_8); 7.84 (m, 1H, C_5); 12.39 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.1 (CH_3); 14.4 (CH_3); 21.5 (CH_2); 22.2 (CH_2); 25.7 (CH_2); 29.2 (CH_2); 31.7 (CH_2); 111.6 (Cq); 113.7 (CH); 120.6 (CH); 124.2 (CH); 124.5 CH); 125.9 (Cq); 137.3 (Cq); 137.5 (Cq); 143.8 (Cq); 145.6 (Cq); 172.9 (C=O); 183.76 (C=O); ms: *m/z* (FD) 295.7 (M^+, 100%); uv (ethanol): λ max 402 nm (ε 3304), λ max 265 nm (ε 20413), λ max 230 nm (ε 22861).

Anal. Calcd. for $C_{19}H_{21}NO_2$: C, 77.26; H, 7.17; N, 4.74. Found: C, 75.13; H, 7.04; N, 4.49.

1-Ethyl-2-*n*-hexyl-4,9-dihydro-3*H*-3,4-carbazoldione (**37**).

This compound was obtained from 2-[(*E/Z*)-1-ethyl-1-octenyl]-indole (**11**) 850 mg (3.33 mmol) as starting educt. Yield 0.56g (54%), mp 206 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.84 (t, *J*=6.8 Hz, 3H, CH_3); 1.18-1.31 (m, 11H, CH_2-CH_3); 2.31 (m, 2H, CH_2); 2.65 (m, 2H, CH_2); 7.22 (m, 2H, C_{6-7}); 7.50 (m, 1H, C_8); 7.83 (m, 1H, C_5); 12.39 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.2 (CH_3); 14.4 (CH_3); 21.5 (CH_2); 22.3 (CH_2); 25.8 (CH_2); 29.2 (CH_2); 29.5 (CH_2); 31.4 (CH_2); 113.7 (Cq); 115.6 (CH); 120.6 (CH); 124.3 (CH); 124.5 (CH); 125.9 (Cq); 137.3 (Cq); 137.5 (Cq); 143.8 (Cq); 145.6 (Cq); 172.9 (C=O); 183.8 (C=O); ms: *m/z* (FD) 309.7 (M^+, 100%); uv (ethanol): λ max 402 nm (ε 4830), λ max 265 nm (ε 28204), λ max 229 nm (ε 33932)

Anal. Calcd. for $C_{20}H_{23}NO_2$: C, 77.28; H, 8.04; N, 4.50. Found: C, 77.18; H, 7.86; N, 4.37.

1-Ethyl-2-*n*-octyl-4,9-dihydro-3*H*-3,4-carbazoldione (**38**).

This compound was obtained from 2-[(*E/Z*)-1-ethyl-1-decenyl]-indole (**12**) 940 mg (3.33 mmol) as starting educt. Yield 0.58g (52%), mp 222 °C (from methanol); $C_{22}H_{27}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 0.84 (m, 3H, CH_3); 1.16-1.36 (m, 15H, CH_2-CH_3); 2.32 (m, 2H, CH_2); 2.66 (m, 2H, CH_2); 7.23 (m, 2H, C_{6-7}); 7.49 (m, 1H, C_8); 7.88 (m, 1H, C_5); 12.41 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.2 (CH_3); 14.4 (CH_3); 21.5 (CH_2); 22.4 (CH_2); 25.8 (CH_2); 28.9 (CH_2); 29.1 (CH_2); 29.3 (CH_2); 29.5 (CH_2); 31.6 (CH_2); 111.6 (Cq); 113.7 (CH); 120.6 (CH); 124.3 (CH); 124.5 (CH); 125.9 (Cq); 137.3 (Cq); 137.5 (Cq); 143.8 (Cq); 145.6 (Cq); 172.9 (C=O); 183.8 (C=O); ms: *m/z* (FD) 337.9 (M^+, 100%); uv (ethanol): λ max 402 nm (ε 7609), λ max 265 nm (ε 45354), λ max 229 nm (ε 56532).

1-(4-Fluorphenyl)-4,9-dihydro-3*H*-3,4-carbazoldione (**39**).

This compound was obtained from 2-[1-(4-fluorphenyl)vinyl]-indole (**13**) 790 mg (3.33 mmol) as starting educt. Yield 0.52g (54%), mp 296 °C (from methanol); $C_{18}H_{10}FNO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 6.18 (s, 1H, C_2); 7.27 (m, 2H, H_{ar}); 7.51 (m, 3H, H_{ar}); 7.75 (m, 2H, H_{ar}); 7.94 (m, 1H, H_{ar}); 12.08 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 113.3 (Cq): 114.3 (CH); 116.4 (CH); 116.6 (CH); 120.8 (CH); 124.5 (CH); 125.04 (CH); 126.09 (Cq); 126.66 (CH); 130.43 (Cq); 130.92 (CH); 131.04 (CH); 138.1 (Cq); 142.8 (Cq); 145.4 (Cq); 162.0 (Cq); 165.3 (Cq); 173.5 (C=O); 183.5 (C=O); ms: *m/z* (FD) 291.7 (M^+, 100%); uv (ethanol): λ max 413 nm (ε 3314), λ max 264 nm (ε 3924), λ max 225 nm (18227).

1-(4-Methoxyphenyl)-4,9-dihydro-3*H*-3,4-carbazoldione (**40**).

This compound was obtained from 4-[1-(2-indolyl)-vinyl]phenylmethylether (**14**) 830 mg (3.33 mmol) as starting educt. Yield 0.60g (59%), mp 266 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 3.86 (s, 3H, OCH_3); 6.14 (s, 1H, C_2); 7.16 (d, *J*=8.6 Hz, 2H, H_{ar}); 7.26 (m, 2H, H_{ar}); 7.53 (m, 1H, H_{ar}); 7.66 (d, *J*=8.6 Hz, 2H, H_{ar}); 7.95 (m, 1H, H_{ar}); 12.08 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 55.8 (CH_3); 113.2 (Cq); 114.4 (CH); 115.0 (2xCH); 120.8 (CH); 124.6 (CH); 125.0 (CH); 125.5 (CH); 126.1 (Cq); 126.2 (Cq); 130.2 (2xCH); 138.1 (Cq); 143.0 (Cq); 146.2 (Cq); 161.5 (Cq); 173.8 (C=O); 183.4 (C=O); ms: *m/z* (FD) 303.7 (M^+, 100%); uv (ethanol): λ max 385 nm (ε 15697), λ max 265 nm (ε 39970), λ max 229 nm (ε 53303).

Anal. Calcd. for $C_{19}H_{13}NO_2$: C, 74.79; H, 4.92; N, 4.59. Found: C, 74.70; H, 4.94; N, 4.82.

1-(3,4-Dimethoxyphenyl)-4,9-dihydro-3*H*-3,4-carbazoldione (**41**).

This compound was obtained from 2-[1-(3,4-dimethoxyphenyl)vinyl]-indole (**15**) 930 mg (3.33 mmol) as starting educt. Yield 0.64g (58%), mp 211 °C (from ethanol); $C_{20}H_{15}NO_4$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 3.86 (s, 6H, OCH_3); 6.22 (s, 1H, C_2); 7.18 (d, *J*=8.1 Hz, 1H, H_{ar}); 7.26 (m, 4H, H_{ar}); 7.54 (m, 1H, H_{ar}); 7.96 (m, 1H, H_{ar}); 12.11 (s; 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 55.8 (CH_3); 56.1 (CH_3); 111.8 (CH); 112.4 (CH); 113.2 (Cq); 114.4 (CH); 120.8 (CH); 121.4 (CH); 124.6 (CH); 125.0 (CH); 125.4 (CH); 126.1 (Cq); 126.3 (Cq); 138.1 (Cq); 143.0 (Cq); 146.4 (Cq); 149.3 (Cq); 151.2 (Cq); 173.8 (C=O); 183.5 (C=O); ms: *m/z* (FD) 333.7 (M^+, 100%); uv (ethanol): λ max 409 nm (ε 9067), λ max 266 nm (ε 32700), λ max 210 nm (ε 53567).

1-Phenyl-4,9-dihydro-3*H*-3,4-carbazoldione (**42**).

This compound was obtained from 2-(1-phenylvinyl)-indole (**16**) 730 mg (3.33 mmol) as starting educt. Yield 0.54g (59%), mp 312 °C (from methanol); $C_{18}H_{11}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 6.18 (s, 1H, C_2); 7.26 (m, 2H, H_{ar}); 7.53 (m, 1H, H_{ar}); 7.62 (m, 3H, H_{ar}); 7.70 (m, 2H, H_{ar}); 7.95 (m, 1H, H_{ar}); 12.08 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 113.3 (Cq); 114.4 (CH); 120.8 (CH); 124.7 (CH); 125.0 (CH); 126.1 (Cq); 126.6 (CH); 128.4 (2xCH); 129.5 (2xCH); 130.7 (CH); 134.0 (Cq); 138.1 (Cq); 142.7 (Cq); 146.4 (Cq); 173.6 (C=O); 183.6 (C=O); ms: *m/z* (FD) 273.7 (M^+, 100%); uv (ethanol): λ max 415 nm (ε 8634), λ max 379 nm (ε 6230), λ max 339 nm (ε 9563), λ max 265 nm (ε 45623), λ max 225 nm (ε 57869).

2-Methyl-1-phenyl-4,9-dihydro-3*H*-3,4-carbazoldione (**43**).

This compound was obtained from 2-[(*E*)-1-phenyl-1-propenyl]-indole (**17**) 770 mg (3.33 mmol) as starting educt. Yield 0.54g (56%), mp 273 °C (from methanol); $C_{18}H_{11}NO_2$, ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.70 (s, 3H, CH_3); 7.20 (m, 2H, H_{ar}); 7.44 (m, 3H, H_{ar}); 7.61 (m, 3H, H_{ar}); 7.87 (d, *J*=7.2 Hz, 1H, H_{ar}); 11.52 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 13.5 (CH_3); 111.5 (Cq); 114.2 (CH); 120.6 (CH); 124.4 (CH); 124.5 (CH); 126.1 (Cq); 128.9 (2xCH); 129.4 (2xCH); 129.5 (CH); 133.4 (Cq); 134.1 (Cq); 137.7 (Cq); 141.2 (Cq); 145.6 (Cq); 173.0 (C=O); 184.2 (C=O); ms: *m/z* (FD) 287.7 (M^+, 100%); uv (ethanol): λ max 408 nm (ε 6897), λ max 265 nm (ε 45287), λ max 226 nm (ε 46207).

1-(4-Methoxyphenyl)-2-methyl-4,9-dihydro-3*H*-3,4-carbazoldione (**44**).

This compound was obtained from 4-[(*E*)-1-(2-indolyl)-1-propenyl]-phenyl-methylether (**18**) 880 mg (3.33 mmol) as starting educt. Yield 0.64g (61%), mp 256 °C (from ethanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.72 (s, 3H, CH_3); 3.85 (s, 3H, OCH_3); 7.19 (m, 4H, H_{ar}); 7.41 (m, 3H, H_{ar}); 7.87 (dd, *J*=1.5 Hz, *J*=1.5 Hz, 1H, H_{ar}); 11.51 (s; 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 13.5 (CH_3); 55.6 (CH_3); 111.4 (Cq); 114.2 (CH); 114.8 (2xCH); 120.5 (CH); 124.4 (CH); 124.4 (CH); 125.4 (Cq); 126.1 (Cq); 130.5 (2xCH); 133.9 (Cq); 137.7 (Cq); 141.2 (Cq); 145.9 (Cq); 160.1 (Cq); 173.1 (C=O); 184.4 (C=O); ms: *m/z* (FD) 317.6 (M^+, 100%); uv (ethanol): λ max 392 nm (ε 8254), λ max 265 nm (ε 38761), λ max 227 nm (ε 62952).

Anal. Calcd. for $C_{20}H_{15}NO_3$: C, 75.70; H, 4.76; N, 4.41. Found: C, 74.94; H, 4.97; N, 4.30.

2-Methyl-1-(3-nitrophenyl)-4,9-dihydro-3*H*-3,4-carbazoldione (**45**).

This compound was obtained from 2-[(*E*)-1-(3-nitrophenyl)-1-propenyl]-indole (**19**) 930 mg (3.33 mmol) as starting educt. Yield 0.59g (53%), mp 266 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.69 (s, 3H, CH_3); 7.22 (m, 2H, H_{ar}); 7.37 (dd, *J*=1.3 Hz, *J*=1.9 Hz, 1H, H_{ar}); 7.90 (m, 3H, H_{ar}); 8.36 (s, 1H, H_{ar}); 8.43 (m, 1H, H_{ar}); 11.62 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 13.4 (CH_3); 111.7 (Cq); 113.9 (CH); 120.6 (CH); 124.1 (CH); 124.4 (CH); 124.5 (CH); 124.7 (CH); 126.1 (Cq); 131.2 (CH); 134.9 (Cq); 135.0 (Cq); 135.9 (CH); 137.7 (Cq); 139.1 (Cq); 145.2 (Cq); 148.6 (Cq); 172.8 (C=O); 183.8 (C=O); ms: *m/z* (FD) 332.8 (M^+, 100%); uv (ethanol): λ max 409 nm (ε 4086), λ max 263 nm (ε 33056), λ max 227 nm (ε 34585).

Anal. Calcd. for $C_{19}H_{12}N_2O_4$: C, 67.56; H, 4.15; N, 8.30. Found: C, 67.39; H, 4.23; N, 8.26.

1-(4-Chlorphenyl)-2-methyl-4,9-dihydro-3*H*-3,4-carbazoldione (**46**).

This compound was obtained from 2-[(*E*)-1-(4-chlorphenyl)-1-propenyl]-indole (**20**) 890 mg (3.33 mmol) as starting educt. Yield 0.66g (62%), mp 278 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.69 (s, 3H, CH_3); 7.19 (m, 2H, H_{ar}); 7.39 (dd, *J*=1.5 Hz, *J*=2.2 Hz, 1H, H_{ar}); 7.49 (m, 2H, H_{ar}); 7.68 (d, 2H, H_{ar}); 7.87 (dd, *J*=1.6 Hz, *J*=1.5 Hz, 1H, H_{ar}); 11.56 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.0 (CH_3); 111.5 (Cq); 114.0 (CH); 120.6 (CH); 124.4 (CH); 124.6 (CH); 126.1 (Cq); 129.6 (2xCH); 131.0 (2xCH); 132.3 (Cq); 134.3 (Cq); 134.4 (Cq); 137.7 (Cq); 140.1 (Cq); 145.4 (Cq); 172.9 (C=O); 184.0 (C=O); ms: *m/z* (FD) 321.7 (M^+, 100%); uv (ethanol): λ max 407 nm (ε 4341), λ max 265 nm (ε 28971), λ max 223 nm (ε 40322).

Anal. Calcd. for $C_{19}H_{12}ClNO_2$: C, 70.92; H, 3.76; N, 4.35. Found: C, 70.30; H, 4.15; N, 4.16.

2-Methyl-1-(1-Biphenyl)-4,9-dihydro-3*H*-3,4-carbazoldione (**47**).

This com-pound was obtained from 2-[(*E*)-1-(1-biphenyl)-1-propenyl]-indole (**21**) 530 mg (3.33 mmol) as starting educt. Yield 0.73g (60%), mp 296 °C (from methanol); ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.78 (s, 3H, CH_3); 7.22 (m, 2H, H_{ar}); 7.43 (m, 2H, H_{ar}); 7.55 (m, 4H, H_{ar}); 7.79 (d, *J*=7.7 Hz, 2H, H_{ar}); 7.89 (m, 3H, H_{ar}); 11.62 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 13.6 (CH_3); 111.6 (Cq); 114.2 (CH); 120.6 (CH); 124.4 (CH); 124.5 (CH); 126.1 (Cq); 127.1 (2xCH); 127.6 (2xCH); 128.2 (CH); 129.5 (2xCH); 129.6 (2xCH); 132.5 (Cq); 134.2 (Cq); 137.8 (Cq); 139.7 (Cq); 141.0 (Cq); 141.1 (Cq); 145.5 (Cq); 173.0 (C=O); 184.2 (C=O); ms: *m/z* (FD) 363.7 (M^+, 100%); uv (ethanol): λ max 379 nm (ε 16232), λ max 261 nm (ε 117753), λ max 228 nm (ε 94638).

Anal. Calcd. For $C_{25}H_{17}NO_2$: C, 82.63; H, 4.71; N, 3.85. Found: C, 81.53; H, 4.86; N, 3.79.

1-(3,4-Dimethoxyphenyl)-2-methyl-4,9-dihydro-3*H*-3,4-carbazoldione (**48**).

This compound was obtained from 2-[(*E*)-1-(3,4-dimethoxyphenyl-1-propenyl]-indole (**22**) 980 mg (3.33 mmol) as starting educt. Yield 0.67g (58%), mp 286 °C (from methanol); $C_{21}H_{17}NO_4$; ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.77 (s, 3H, CH_3); 3.79 (s, 3H, OCH_3); 3.85 (s, 3H, OCH_3); 6.99 (dd, *J*=2.0 Hz, *J*=1.7 Hz, 1H, H_{ar}); 7.06 (d, *J*=1.7 Hz, 1H, H_{ar}); 7.19 (m, 3H, H_{ar}); 7.43 (d, *J*=6.9 Hz, 1H, H_{ar}); 7.88 (d, *J*=8.1 Hz, 1H, H_{ar}); 11.54 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 13.6 (CH_3); 55.9 (2xCH_3); 111.4 (Cq); 112.4 (CH); 112.5 (CH); 114.2 (CH); 120.5 (CH); 121.6 (CH); 124.4 (CH); 124.5 (CH); 125.5 (Cq); 126.1 (Cq); 133.9 (Cq); 137.7 (Cq); 141.4 (Cq); 145.9 (Cq); 149.3 (Cq); 149.7 (Cq); 172.8 (C=O); 184.4 (C=O); ms: *m/z* (FD) 347.7 (M^+, 100%); uv nm (ethanol): λ max 404 nm (ε 2188), λ max 379 nm (ε 1840), λ max 359 nm (ε 1354), λ max 265 nm (ε 11285), λ max 229 nm (ε 14861).

2-Methyl-1-(l-naphthyl)-4,9-dihydro-3*H*-3,4-carbazoldione (**49**).

This compound was obtained from 2-[(*E*)-1-(1-naphthyl)-1-propenyl]-indole (**23**) 940 mg (3.33 mmol) as starting educt. Yield 0.66g (59%), mp 264 °C (from methanol); $C_{23}H_{15}NO_2$; ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.53 (s, 3H, CH_3); 7.14 (m, 1H, H_{ar}); 7.24 (m, 2H, H_{ar}); 7.50 (m, 1H, H_{ar}); 7.60 (m, 2H, H_{ar}); 7.72 (m, 1H, H_{ar}); 7.93 (m, 2H, H_{ar}); 8.08 (d, *J*=7.9 Hz, 1H, H_{ar}); 8.14 (d, *J*=8.4 Hz, 1H, H_{ar}); 11.38 (s, 1H, NH); ^{13}C nmr

(dimethylsulfoxide-d_6): δ 13.5 (CH_3); 111.6 (Cq); 113.9 (CH); 120.6 (CH); 124.3 (CH); 124.4 (CH); 125.4 (CH); 126.2 (Cq); 126.3 (CH); 126.9 (2xCH); 127.4 (CH); 128.9 (CH); 129.7 (CH); 130.7 (Cq); 130.9 (Cq); 133.8 (Cq); 135.9 (Cq); 137.7 (Cq); 139.7 (Cq); 146.0 (Cq); 173.3 (C=O); 183.8 (C=O); ms: *m/z* (FD) 337.7 (M^+, 100%); uv (ethanol): λ max 404 nm (ε 9054), λ max 266 nm (ε 55676), λ max 222 nm (ε 166419).

1-(3-Indolyl)-2-methyl-4,9-dihydro-3,4-carbazoldion (**50**).

This compound was obtained from 2-[(*E*)-1-(3-indolyl)-1-propenyl]-indole (**24**) 910 mg (3.33 mmol) as starting educt. Yield 0.64g (58%), mp 276 °C (from methanol); $C_{21}H_{14}N_2O_2$; ^{1}H nmr (dimethylsulfoxide-d_6): δ 1.80 (s, 3H, CH_3); 7.10 (m, 1H, H_{ar}); 7.20 (m, 3H, H_{ar}); 7.37 (m, 2H, H_{ar}); 7.55 (d, *J*=8.1 Hz, 1H, H_{ar}); 7.78 (d, *J*=2.7 Hz, 1H, H_{ar}); 7.89 (d, *J*=6.9 Hz, 1H, H_{ar}); 11.61 (s, 1H, NH); 11.88 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.4 (CH_3); 107.4 (Cq); 111.4 (Cq); 112.5 (CH); 114.1 (CH); 120.1 (CH); 120.3 (CH); 120.5 (CH); 122.3 (CH); 124.3 (CH); 124.3 (CH); 126.2 (Cq); 126.3 (Cq); 127.7 (CH); 133.9 (Cq); 136.0 (Cq); 136.6 (Cq); 137.5 (Cq); 146.5 (Cq); 173.3 (C=O); 184.0 (C=O); ms: *m/z* (FD) 326.8 (M^+, 100%); uv (ethanol): λ max 419 nm (ε 9608) λ max 267 nm (ε 44771), λ max 219 nm (ε 86797).

1-(3-Indolyl)-4,9-dihydro-3*H*-3,4-carbazoldione (**51**).

This compound was obtained from 2-[1-(3-indolyl)vinyl]-indole (**25**) 860 mg (3.33 mmol) as starting educt. Yield 0.45g (43%), mp 272 °C (from methanol); $C_{20}H_{12}N_2O_2$; ^{1}H nmr (dimethylsulfoxide-d_6): δ 6.39 (s, 1H, C_2); 7.26 (m, 4H, H_{ar}); 7.58 (m, 2H, H_{ar}); 7.81 (d, *J*=7.5 Hz, 1H, H_{ar}); 7.99 (m, 1H, H_{ar}); 8.16 (d, *J*=2.6 Hz, 1H, H_{ar}); 12.24 (s, 2H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 108.7 (Cq); 112.9 (CH); 114.4 (CH); 120.2 (CH); 120.8 (CH); 121.5 (CH); 121.6 (CH); 123.3 (CH); 124.5 (CH); 124.9 (CH); 125.3 (Cq); 126.0 (Cq); 130.6 (CH); 137.5 (Cq); 138.0 (Cq); 140.8 (Cq); 143.4 (Cq); 150.3 (Cq); 174.4 (C=O); 182.9 (C=O); ms: *m/z* (FD) 312.6 (M^+, 100%); uv (ethanol): λ max 431 nm (ε 1732), λ max 379 nm (ε 952), λ max 266 nm (ε 6069), λ max 218 nm (ε 12637).

2-Ethyl-1-phenyl-4,9-dihydro-3*H*-3,4-carbazoldione (**52**).

This compound was obtained from 2-[(*E*)-1-phenyl-1-butenyl]-indole (**26**) 820 mg (3.33 mmol) as starting educt. Yield 0.64g (64%), mp 288 °C (from methanol); ^{1}H nmr (300 MHz, dimethylsulfoxide-d_6): δ 0.88 (t, *J*=7.4 Hz, 3H, CH_3); 2.09 (dd, *J*=6.9 Hz, *J*=7.1, 2H, CH_2); 7.20 (m, 2H, H_{ar}); 7.43 (m, 3H, H_{ar}); 7.60 (m, 3H, H_{ar}); 7.87 (d, *J*=7.7 Hz, 1H, H_{ar}); 11.49 (s, 1H, NH); ^{13}C nmr (dimethylsulfoxide-d_6): δ 14.2 (CH_3); 20.5 (CH_2); 111.5 (Cq); 114.2 (CH); 120.6 (CH); 124.4 (CH); 124.5 (CH); 126.1 (Cq); 128.5 (2xCH); 129.5 (3xCH); 133.3 (Cq); 137.8 (Cq); 139.5 (Cq); 141.6 (Cq); 145.6 (Cq); 172.9 (C=O); 183.8 (C=O); ms: *m/z* (FD) 301.8 (M^+, 100%); uv (ethanol): λ max 408 nm (ε 10240), λ max 324 nm (ε 2952), λ max 265 nm (ε 53976), λ max 227 nm (ε 67892).

Anal. Calcd for $C_{20}H_{15}NO_2$: C, 79.52; H, 5.02; N, 4.65. Found: C, 79.52; H, 5.24; N, 4.62

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REFERENCES AND NOTES

[1] P. Bhattacharyya and D. P. Chakraborty in Prog. Chem. Org. Nat. Prod., Vol. **52**; W. Herz, H. Grisebach, G. W. Kirby, Eds.; Springer, Wien, 1987, p. 159; D. P. Chakraborty, and S. Roy in Prog. Chem. Org. Nat. Prod., Vol. **57**; W. Herz, H. Grisebach, G.W. Kirby, C. Tamm, Eds.; Springer, Wien, 1991, p. 71; D. P. Chakraborty in The Alkaloids, Vol. **44**; A. Brossi, Ed.; Academic Press, New York, 1993, p. 257.

[2] J. Bergman and B. Pelcman, *Pure Appl. Chem.*, **62**, 1967 (1990); U. Pindur, *Chimia*, **44**, 406 (1990); C. J. Moody, *Synlet*t, 681 (1994); H.-J. Knölker *in Advances in Nitrogen Heterocycles*, Vol. **1**, C. J. Moody, Ed.; JAI Press, Greenwich (CT) 1995, p. 173.

[3] S. Kato, H. Kawai, T. Kawasaki, Y. Toda, T. Urata and Y. Hayakawa, *J. Antibiot.*, **42**, 1879 (1989).

[4] M. Tanaka, K. Shin-ya, K. Furihata and H. Seto, *J. Antibiot.*, **48**, 326 (1995).

[5] K. Shin-ya, M. Tanaka, K. Furihata, Y. Hayakawa and H. Seto, *Tetrahedron Lett*., **34**, 4943 (1993).

[6] K. Shin-ya, S. Shimizu, T. Kunigami, K. Furihata and H. Seto, *J. Antibiot*., **48**, 574 (1995).

[7] T. Choshi, H. Fujimoto and S. Hibino, *Heterocyles*, **43**, 1847 (1996).

[8] B. Hammond, H. A. Kantos and M. L. Hess, *Can. J. Physiol. Pharmacol.*, **63**, 173 (1985); P. A. Cerutti, *Science*, **227**, 375 (1985); B. Halliwell and J. M. C. Gutteridge, *Method in Enzymology*,**186**, 1 (1990).

[9] K. Shin and K. Ogasawara, *Synlett*, 922 (1996)

[10] T. Coshi, T. Sada, H. Fujimoto, C. Nagayama, E. Sugino and H. Hibino, *J. Org. Chem.*, **62**, 2535 (1997).

[11] H.-J. Knölker and W. Fröhner, *Tetrahedron Lett.*, **38**, 1535 (1997).

[12] H.-J. Knölker and W. Fröhner, *Synlett*, 1108 (1997).

[13] H.-J.Knölker and W. Fröhner, *Tetrahedron Lett.*, **39**, 2537 (1998).

[14] H.-J. Knölker, K. R. Reddy and A. Wagner, *Tetrahedron Lett.*, **39**, 8267 (1998); H.-J. Knölker and K. R. Reddy, *Synlett*, 596 (1999).

[15] A. Aygün and U. Pindur, *Synlett*, **12**, 1757 (2000).

[16] T. Lemster and U. Pindur, *Recent Research Devel. In. Org. & Bioorg. Chem.*, **6** (2002) in press.

[17] G. Dannhardt, and L. Flemmer, *Arch. Pharm. Pharm. Med. Chem.*, **331**, 359 (1998).

[18] D. Ledergerber and R. W. Hartmann, *J. Enzyme. Inhibi.*, **9**, 253 (1995).

[19] R. H. K. Morris and G. G. Davies, *Ann. Clin. Biochem.*, **30**, 203 (1993).

[20] V. Roubaud, S. Sankarapandi, P. Kuppusamy, P. Tordo, and J. L. Zweier, *Anal. Biochem.*, **257**, 210 (1998).

[21] K. W. Kohn and R. A. G., *Cancer Res.*, **33**, 1849(1973).

[22] K. W. Kohn and L. C. Erickson, *Biochemistry*, **15**, 4629 (1976).

[23] A. Aygün, Thesis, 2002, *University of Mainz*, Mainz. Germany.

[24] N. Macias-Ruvalcaba, G. Cuevas, I. Gonzalez, M. Aquilar-Martinez, *J. Org. Chem.*, **67**, 3673 (2002).