A New Reaction of Isatin, Cyclic 1,3-Diketone, and 2-Cyanoacetamide: A Four-Component Synthesis of Spirooxindoles

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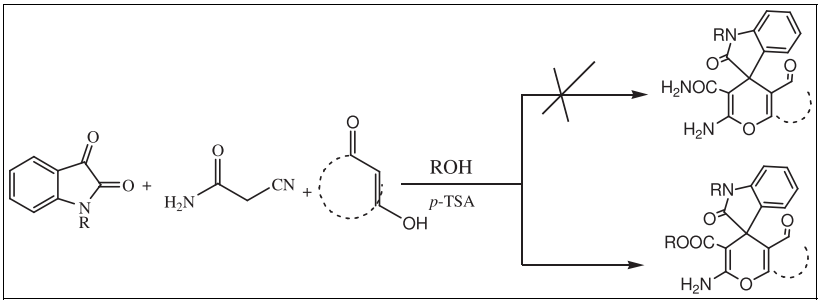

A novel reaction of isatins, 2-cyanoacetamide, and cyclic 1,3-diketones in ethanol was reported. The reaction gave the unexpected spirooxindole ethyl carboxylates in excellent yields and the spirooxindole carboxamide was not observed.

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INTRODUCTION

Multicomponent reactions (MCRs), in which several reactions are combined into one synthetic operation have been used extensively to form carbon–carbon bonds [1–3]. Such reactions offer a wide range of possibilities for the efficient construction of highly complex molecules in a single step, thus avoiding complicated purification operations and allowing savings of both solvents and reagents. There has been tremendous development in MCRs, and significant efforts continue to be made to develop new MCRs [4–7]. In this context, spirooxindoles show interesting features which make them attractive targets for the synthesis via MCRs.

The heterocyclic spirooxindoles are attractive targets in organic synthesis because of their highly pronounced biological activities as well as wide-ranging utility as synthetic intermediates for alkaloids, drug candidates, and clinical pharmaceuticals [8,9]. Therefore, searching for efficient methods for the synthesis of these compounds is interesting in organic synthesis, and numerous impressive successes have been recorded for the synthesis of diversely structured spirocyclic oxindoles over the past years [10,11]. Although three-component reactions of malononitrile or cyanoacetic esters, isatins, and 1,3-dicarbonyl compounds is the one of the powerful methods for the synthesis of spirooxindoles (Scheme 1) [12–19], utilization of 2-cyanoacetamide has not been reported yet.

In continuation of our previous works on synthesis of spirooxindoles [12–25], herein, we envisioned that the use of 2-cyanoacetamide instead of malononitrile or cyanoacetic esters in the three-component reaction with isatins and 1,3-dicarbonyl compounds might be a novel method to achieve new spirooxindole carboxamides **4** (Scheme 2).

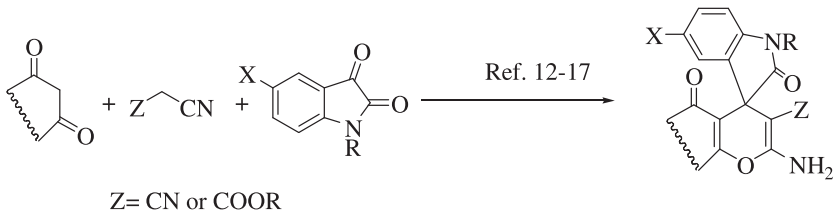
RESULTS AND DISCUSSION

In a pilot experiment, the reaction of 3-hydroxy-1*H*-phenalen-1-one **1**, 2-cyanoacetamide **2**, and isatin **3a** in the presence of Et_3N (15 mol%) as an inexpensive and available catalyst proceeded rapidly in refluxing ethanol. The progress of the reaction was monitored by TLC. After completion of the reaction after 10 h, the expected spirooxindole carboxamide **4** was not observed; unexpectedly, ethanol acted as a fourth reactant and afforded the corresponding spirooxindole ethyl carboxylate **5a** (Scheme 2).

Encouraged by this success, in order to improve the yield, we performed the reaction using different quantities of EtOH. The best result was obtained with a 1:1:1:3 ratios of 3-hydroxy-phenalen-1-one, 2-cyanoacetamide, isatin, and ethanol.

Then, we extended the reaction of 3-hydroxy-phenalen-1-one **1** (1 mmol) and 2-cyanoacetamide **2** (1 mmol) with various isatins **3** (1 mmol) and alcohols (3 mmol). Corresponding alkyl 10′-amino-2,7′-dioxo-7′*H*-spiro

Scheme 1



[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylates **5a**–**c**′ were synthesized in good yields in the presence of Et_3N (15 mol%). The optimized results are summarized in Table 1.

For the investigation of the reaction mechanism, it is notable that, when this reaction was carried out in the absence of ethanol and in solvent-free conditions or in other solvent such as CH_3CN, $CHCl_3$, CH_2Cl_2, and THF, the TLC and ^{1}H-NMR spectra of the reaction mixture showed a combination of starting materials and numerous products. Also, alkyl 10′-amino-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate **5** is the main product of the reaction and other by-products (Fig. 1) were not identified. On the other hand, it is known [17,18] that the reaction of isatins, 1,3-dicarbonyl compounds, and alkyl cyanoacetates gives alkyl spirooxindole carboxylate derivatives.

According to the results, the selectivity in the synthesis of **5** can be explained by the strict sequence of reactions in Scheme 3. It is reasonable to assume that **5** results from fast initial formation of intermediate isatylidene cyanoacetate **7** [12–18] by standard Knoevenagel condensation of the isatin **3** and alkyl cyanoacetate **6** (formed *in situ* by nucleophilic reaction of **2** and alcohol). Then, the subsequent Michael-type addition of **1** to the intermediate **7**, followed by cyclization and tautomerization affords the corresponding products **5**.

To further explore the potential of this protocol, we investigated reaction of dimedone **6** with 2-cyanoacetamide **2**, isatins **3**, and alcohols and obtained alkyl 2-amino-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate **7** in good yields under same reaction conditions (Table 2).

Compounds **5** and **7** are stable solids whose structures were established by IR, ^{1}H-NMR, ^{13}C-NMR spectroscopy, and elemental analysis.

In conclusion, we have developed a new simple four-component method for the synthesis of spirooxindoles via the reaction of isatins, 2-cyanoacetamide, cyclic 1,3-diketones, and alcohols. Prominent among the advantages of this new method are novelty, operational simplicity, and good yields of the products. We believe this method will find useful applications in the growth of spirooxindole chemistry.

EXPERIMENTAL

Melting points were measured on an Elecrtothermal 9100 apparatus. Mass spectra were recorded on a FINNIGAN-MAT 8430 mass spectrometer operating at an ionization potential of 70 eV. ^{1}H and ^{13}C-NMR spectra were recorded on a BRUKER DRX-300 AVANCE spectrometer at 300.13 and and 75.47 MHz, respectively. IR spectra were recorded using a Shimadzu IR-470 apparatus. Elemental analyses were performed using a Heracus CHN-O-Rapid analyzer.

General procedure for the preparation of spirooxindoles 5 or 7. A mixture of cyclic 1,3-diketone (1 mmol), 2-cyanoacetamide (1 mmol), isatin (1 mmol), alcohol (3 mmol), and Et_3N (15 mol%) was stirred at appropriate temperature (Tables 1 and 2) for 10 h (the progress of the reaction was

Scheme 2

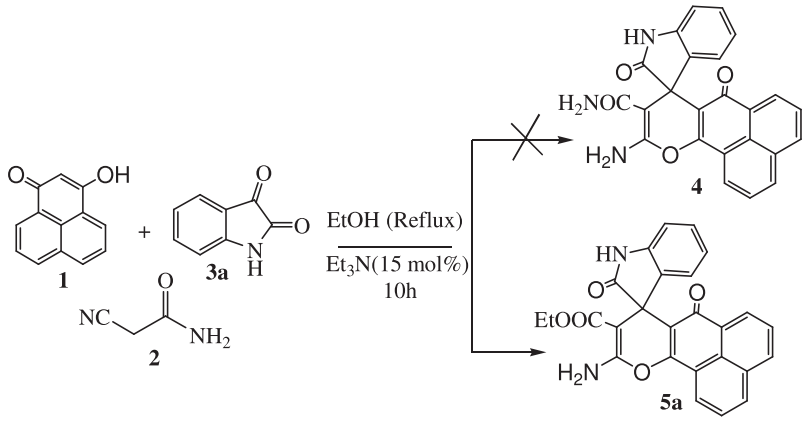
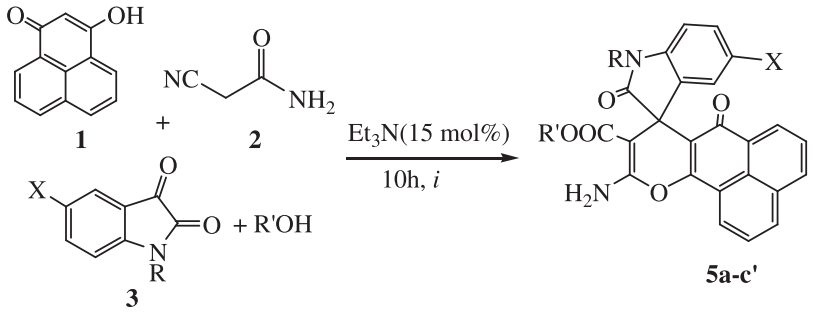


Table 1

Synthesis of spirooxindole **5**.



i= Reaction temprature for MeOH= 50 °C and for other alcohol= 70 °C

Product **5**	R	X	R′	Yield (%)
a	H	H	CH_3	95
b	H	Br	CH_3	92
c	Me	Br	CH_3	90
d	Et	Br	CH_3	87
e	H	NO_2	CH_3	96
f	Me	H	CH_3	91
g	H	H	CH_3CH_2	92
h	H	Br	CH_3CH_2	94
i	Me	Br	CH_3CH_2	85
j	Et	Br	CH_3CH_2	83
k	H	NO_2	CH_3CH_2	95
l	Me	NO_2	CH_3CH_2	86
m	Me	H	CH_3CH_2	93
n	H	Me	CH_3CH_2	88
o	H	H	$CH_3CH_2CH_2$	90
p	Me	Br	$CH_3CH_2CH_2$	84
q	Et	Br	$CH_3CH_2CH_2$	82
r	H	Br	$(CH_3)_2CH$	91
s	H	NO_2	$(CH_3)_2CH$	90
t	Me	H	$(CH_3)_2CH$	85
u	H	H	$CH_3CH_2CH_2CH_2$	88
v	H	Br	$CH_3CH_2CH_2CH_2$	90
w	H	NO_2	$CH_3CH_2CH_2CH_2$	93
x	H	H	$CH_3CH_2CH_2CH_2CH_2$	90
y	H	Br	$CH_3CH_2CH_2CH_2CH_2$	91
z	H	NO_2	$CH_3CH_2CH_2CH_2CH_2$	94
a′	H	H	$CH_3CH_2CH\ (CH_3)CH_2$	86
b′	H	Br	$CH_3CH_2CH\ (CH_3)CH_2$	87
c′	H	NO_2	$CH_3CH_2CH\ (CH_3)CH_2$	89

monitored by TLC). After completion, H_2O (5 mL) was added and the reaction mixture was filtered and the precipitate washed with H_2O (5 mL) and EtOH (5 mL) to afford pure product.

Methyl 10′- amino -2,7′- dioxo -7′*H* - spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5a). Yellow powder (95%); m.p.: 285–287°C. IR (KBr) (ν_{max}/cm^{-1}): 3443, 3404, 1731, 1679. MS (EI, 70 eV) *m/z*: 424 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 3.33 (3H, s, OMe), 6.73–8.53 (10H, m, H-Ar), 8.05 (2H, bs, NH_2), 10.39 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 48.2, 50.7, 76.7, 108.7, 115.9, 121.1, 121.3, 123.2, 125.2, 127.3, 127.7, 127.8, 128.0, 130.3, 131.8, 133.7, 135.7, 136.2, 144.6., 154.2, 159.4, 168.0, 180.4, 181.0. Analysis calculated for $C_{25}H_{16}N_2O_5$: C, 70.75; H, 3.80; N, 6.60. Found: C, 70.65; H, 3.74; N, 6.52.

Methyl 10′-amino-5-bromo-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5b). Yellow powder (92%); m.p.: 296–287°C. IR (KBr) (ν_{max}/cm^{-1}): 3443, 3382, 1718, 1688. MS (EI, 70 eV) *m/z*: 504 (M^+), 502 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 3.33 (3H, s, OMe), 6.74–8.54 (9H, m, H-Ar), 8.07 (2H, bs, NH_2), 10.50 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 48.4, 59.5, 75.9, 110.6, 112.7, 115.1, 121.4, 125.3, 126.0, 127.3, 127.6, 127.9, 130.5, 131.8, 133.8, 135.8, 138.9, 144.3, 154.5, 159.6, 167.8, 180.0, 181.2. Analysis calculated for $C_{25}H_{15}BrN_2O_5$: C, 59.66; H, 3.00; N, 5.56. Found: C, 59.58; H, 3.07; N, 5.51.

Methyl 10′-amino-5-bromo-1-methyl-2,7′-dioxo-7′*H*-spiro [indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5c). Yellow powder (90%); m.p.: 291–292°C. IR (KBr) (ν_{max}/cm^{-1}): 3299, 1726, 1683. MS (EI, 70 eV) *m/z*: 518 (M^+), 516 (M^+).

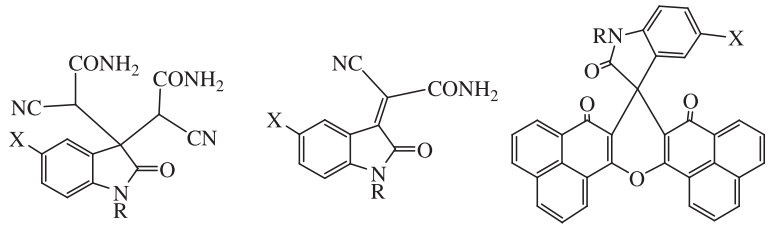


Figure 1. Probable by-products of the reaction.

^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 3.23 (3H, s, NMe), 3.37 (3H, s, OMe), 6.92–8.54 (9H, m, H-Ar), 8.13 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 26.9, 47.8, 51.1, 75.9, 109.5, 113.6, 114.9, 121.3, 125.3, 125.9, 127.3, 127.5, 127.8, 128.0, 130.5, 130.8, 131.8, 133.9, 135.9, 137.7,145.4, 154.8, 159.5, 167.7, 178.5, 181.2. Analysis calculated for $C_{26}H_{17}BrN_2O_5$: C, 60.36; H, 3.31; N, 5.42. Found: C, 60.45; H, 3.38; N, 5.31.

Methyl 10′-amino-5-bromo-1-ethyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8'-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5d). Yellow powder (87%); m.p.: 289–290°C. IR (KBr) (ν_{max}/cm^{-1}): 3299, 1706, 1681. MS (EI, 70 eV) *m/z*: 532 (M^+), 530 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 1.27 (3H, bs, Me), 3.35 (2H, m, NCH_2), 3.38 (3H, s, OMe), 6.95–8.55 (9H, m, H-Ar), 8.16 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 11.7, 30.0, 35.2, 48.4, 109.5, 113.3, 114.2,1 20.9, 121.2, 125.7, 126.8, 127.3, 127.8, 130.4, 131.8, 133.0, 134.0, 135.9, 142.0, 158.6, 159.1, 159.7, 164.3, 175.3, 180.7. Analysis calculated for $C_{27}H_{19}BrN_2O_5$: C, 61.03; H, 3.60; N, 5.27. Found: C, 60.91; H, 3.52; N, 5.18.

Methyl 10′-amino-5-nitro-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5e). Yellow powder (96%); m.p.: 289–291°C. IR (KBr) (ν_{max}/cm^{-1}): 3431, 3371, 1716, 1690. MS (EI, 70 eV) *m/z*: 469 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 3.37 (3H, s, OCH_3), 6.98–8.56 (9H, m, H-Ar), 8.17 (2H, bs, NH_2), 11.20 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 48.3, 50.9, 75.7, 108.6, 114.5, 118.9, 121.2, 125.3, 125.8, 127.3, 127.5, 127.8, 128.2, 130.5, 131.8, 134.3, 136.3, 137.4, 142.1, 151.5, 155.0, 159.5, 167.6, 181.1, 181.3. Analysis calculated for $C_{25}H_{15}N_3O_7$: C, 63.97; H, 3.22; N, 8.95. Found: C, 63.88; H, 3.14; N, 8.84.

Methyl 10′-amino-1-methyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5f). Yellow powder (91%); m.p.: 287–288°C. IR (KBr) (ν_{max}/cm^{-1}): 3299, 1708, 1681. MS (EI, 70 eV) *m/z*: 438 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 3.18 (3H, s, NMe), 3.32 (3H, s, OMe), 6.82–8.58 (10H, m, H-Ar), 8.08 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 26.9, 47.6, 51.0, 57.7, 76.5, 107.6, 115.7, 121.2, 121.9, 123.0, 125.3, 127.3, 127.6, 127.8, 128.2, 130.4, 131.8, 133.8, 135.2, 135.8, 145.9, 154.4, 159.4, 167.8, 178.8, 181.0. Analysis calculated for $C_{26}H_{18}N_2O_5$: C, 71.23; H, 4.14; N, 6.39. Found: C, 71.34; H, 4.08; N, 6.32.

Ethyl 10′-amino-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5g). Yellow powder (92%); m.p.: 291–293°C. IR (KBr) (ν_{max}/cm^{-1}): 3360, 3261, 1688, 1623. MS (EI, 70 eV) *m/z*: 438 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.86 (3H, bs, Me), 3.77 (2H, m, OCH_2), 6.32–8.52 (10H, m, H-Ar), 8.10 (2H, bs, NH_2), 10.37 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 13.7, 48.2, 59.4, 76.4, 108.7,115.9, 121.1, 121.3, 123.1, 125.2, 127.3, 127.7, 127.8, 130.3, 131.8, 133.6, 135.77, 136.4, 144.9, 154.2, 159.5, 168.0, 180.4, 181.1. Analysis calculated for $C_{26}H_{18}N_2O_5$: C, 71.23; H, 4.14; N, 6.39. Found: C, 71.37; H, 4.06; N, 6.49.

Ethyl 10′-amino-5-bromo-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5h). Yellow powder (94%); m.p.: 294–295°C. IR (KBr) (ν_{max}/cm^{-1}): 3344, 3249, 1689, 1621. MS (EI, 70 eV) *m/z*: 518 (M^+), 516 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.90 (3H, t, J = 7.1Hz, Me), 3.79–3.85 (2H, m, OCH_2), 6.73–8.55 (9H, m, H-Ar), 8.17 (2H, bs, NH_2), 10.56 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 13.7, 48.4, 59.5, 75.9, 110.6, 112.7, 115.2, 121.4, 125.3, 126.0, 127.3, 127.6, 127.9, 130.4, 130.5, 131.8, 133.8, 135.8, 138.9, 144.4, 154.6, 159.6, 167.9, 180.0, 181.2. Analysis calculated for $C_{26}H_{17}BrN_2O_5$: C, 60.36; H, 3.31; N, 5.42. Found: C, 60.25; H, 3.23; N, 5.51.

Scheme 3

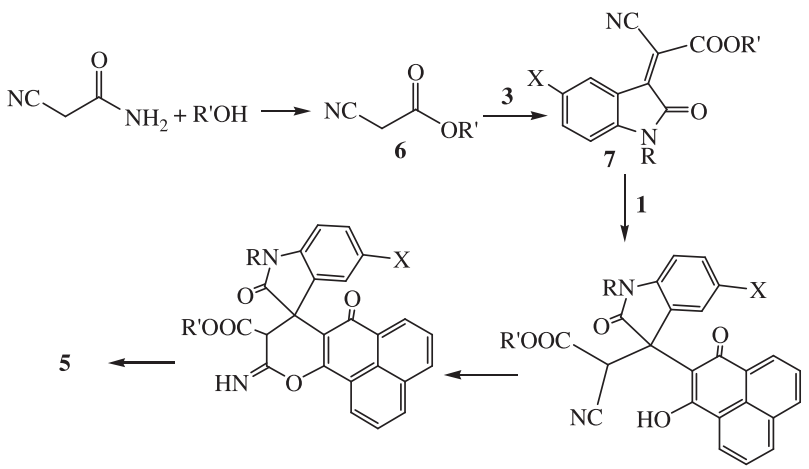
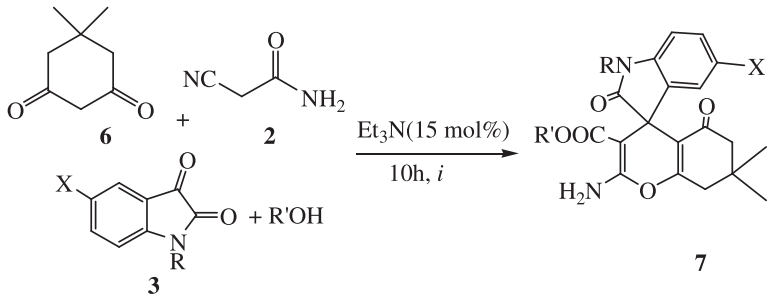


Table 2

Synthesis of spirooxindole **7**.



i= Reaction temprature for MeOH= 50 °C and for other alcohol= 70 °C

Product **7**	R	X	R′	Yield (%)
a	H	H	CH_3	90
b	H	Br	CH_3	89
c	Me	Br	CH_3	91
d	H	NO_2	CH_3	85
e	H	H	CH_3CH_2	91
f	H	Br	CH_3CH_2	88
g	Me	Br	CH_3CH_2	84
h	H	NO_2	CH_3CH_2	89
i	H	H	$CH_3CH_2CH_2$	87
j	H	Br	$CH_3CH_2CH_2$	85
k	H	NO_2	$CH_3CH_2CH_2$	83
l	H	H	$(CH_3)_2CH$	92
m	H	NO_2	$(CH_3)_2CH$	89
n	H	Br	$(CH_3)_2CH$	86
o	H	H	$CH_3CH_2CH_2CH_2$	84
p	H	NO_2	$CH_3CH_2CH_2CH_2$	90
q	H	H	$CH_3CH_2CH_2CH_2CH_2$	88

Ethyl 10′-amino-5-bromo-1-methyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5i). Yellow powder (85%); m.p.: 290–291°C. IR (KBr) (ν_{max}/cm^{-1}): 3272, 1713, 1682. MS (EI, 70 eV) *m/z*: 532 (M^+), 530 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.80 (3H, bs, Me), 3.20 (3H, s, NMe), 3.75 (2H, bs, OCH_2), 6.92–8.50 (9H, m, H-Ar), 8.20 (2H, bs, NH_2). Analysis calculated for $C_{27}H_{19}BrN_2O_5$: C, 61.03; H, 3.60; N, 5.27. Found: C, 60.95; H, 3.53; N, 5.36. (Due to the very low solubility of product **5i**, we were unable to obtain the ^{13}C-NMR spectrum).

Ethyl 10′-amino-5-bromo-1-ethyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5j). Yellow powder (83%); m.p.: 284–285°C. IR (KBr) (ν_{max}/cm^{-1}): 3266, 1683, 1639. MS (EI, 70 eV) *m/z*: 546 (M^+), 544 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.79 (3H, bs, Me), 1.31 (3H, bs, Me), 3.72 (3H, bs, NCH_2), 3.83 (2H, bs, OCH_2), 6.97–8.52 (11H, m, H-Ar and NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 12.5, 14.2, 35.0, 41.6, 59.2, 75.6, 109.4, 113.4, 115.6, 126.0, 126.5, 127.3, 127.5, 127.9, 130.5, 130.7, 131.8, 133.9, 135.8, 138.2, 144.7, 154.6, 159.7, 167.7, 177.8, 180.4. Analysis calculated for $C_{28}H_{21}BrN_2O_5$: C, 61.66; H, 3.88; N, 5.14. Found: C, 61.77; H, 3.81; N, 5.23.

Ethyl 10′-amino-5-nitro-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5k). Yellow powder (95%); m.p.: 299–300°C. IR (KBr) (ν_{max}/cm^{-1}): 3409, 3266, 1793, 1734. MS (EI, 70 eV) *m/z*: 483 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.89 (3H, t, J = 7.0 Hz, Me), 3.77–3.84 (2H, m, OCH_2), 6.98–8.55 (9H, m, H-Ar), 8.24 (2H, bs, NH_2), 11.20 (1H, s, NH). Analysis calculated for $C_{26}H_{17}N_3O_7$: C, 64.60; H, 3.54; N, 8.69. Found: C, 64.48; H, 3.61; N, 8.59. (Due to the very low solubility of product **5k**, we were unable to obtain the ^{13}C-NMR spectrum).

Ethyl 10′-amino-1-methyl-5-nitro-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5l). Yellow powder (86%); m.p.: 294–295°C. IR (KBr) (ν_{max}/cm^{-1}): 3294, 1722, 1683. MS (EI, 70 eV) *m/z*: 497 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.81 (3H, t, J = 6.6 Hz, Me), 3.35 (3H, s, NMe), 3.75–3.78 (2H, bs, OCH_2), 7.21–8.58 (9H, m, H-Ar), 8.29 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.2, 27.2, 47.5, 59.5, 74.1, 107.6, 114.4, 118.7, 121.2, 125.4, 125.9, 127.3, 127.4, 12.9, 128.3, 130.6, 131.8, 134.2, 136.1, 136.6, 142.7, 152.2, 155.1, 159.9, 167.4, 179.6, 181.4. Analysis calculated for $C_{27}H_{19}N_3O_7$: C, 65.19; H, 3.85; N, 8.45. Found: C, 65.27; H, 3.79; N, 8.52.

Ethyl 10′-amino-1-methyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5m). Yellow powder (93%); m.p.: 283–285°C. IR (KBr) (ν_{max}/cm^{-1}): 3299, 1710, 1679. MS (EI, 70 eV) *m/z*: 452 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.79 (3H, t, J = 6.9 Hz, Me), 3.23 (3H, s, NMe), 3.72–3.74 (2H, bs, OCH_2), 6.81–8.54 (10H, m, H-Ar), 8.16 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.0, 26.8, 47.6, 59.3, 76.1, 107.5, 115.7, 121.2,121.9, 123.0, 125.3, 127.3, 127.6, 127.8, 128.2, 130.4, 131.8, 133.8, 135.4, 135.8, 146.0, 154.3, 159.6, 167.9, 178.7, 181.1. Analysis calculated for $C_{27}H_{20}N_2O_5$: C, 71.67; H, 4.46; N, 6.19. Found: C, 71.54; H, 4.40; N, 6.13.

Ethyl 10′-amino-5-methyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5n). Yellow powder (88%); m.p.: 296–297°C. IR (KBr) (ν_{max}/cm^{-1}): 3360, 3244, 1688, 1627. MS (EI, 70 eV) *m/z*:

452 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.90 (3H, t, J = 7.2 Hz, Me), 2.09 (3H, s, Me), 3.75–3.82 (2H, bs, OCH_2), 6.64–8.53 (9H, m, H-Ar), 8.10 (2H, bs, NH_2), 10.28 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 13.6, 21.0, 48.2, 59.5, 76.6, 108.5, 116.0, 121.4, 123.9, 125.3, 127.3, 127.6, 127.7, 127.8, 128.3,129.7, 130.3, 131.8, 133.6, 135.7, 136.4, 142.4, 154.1, 159.4, 168.0, 180.3, 181.0. Analysis calculated for $C_{27}H_{20}N_2O_5$: C, 71.67; H, 4.46; N, 6.19. Found: C, 71.51; H, 4.38; N, 6.26.

Propyl 10′-amino-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5o). Yellow powder (90%); m.p. 254–255°C. IR (KBr) (ν_{max}/cm^{-1}): 3398, 3277, 1793, 1717. MS (EI, 70 eV) *m/z*: 452 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.59 (3H, t, J = 7.4 Hz, Me), 1.26–1.35 (2H, m, CH_2), 3.68–3.78 (2H, m, OCH_2), 6.73–8.54 (10H, m, H-Ar), 8.12 (2H, bs, NH_2), 10.37 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 10.7, 21.5, 48.1, 65.3, 76.5, 108.8, 116.0, 121.1, 121.4, 123.2, 125.3, 127.3, 127.7, 127.8, 127.8, 130.3, 131.8, 133.6, 135.7, 136.3, 144.8, 154.1, 159.6, 168.2, 180.3, 181.0. Analysis calculated for $C_{27}H_{20}N_2O_5$: C, 71.67; H, 4.46; N, 6.19. Found: C, 71.74; H, 4.39; N, 6.11.

Propyl 10′-amino-5-bromo-1-methyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5p). Yellow powder (84%); m.p. 288–290°C. IR (KBr) (ν_{max}/cm^{-1}): 3288, 1710, 1682. MS (EI, 70 eV) *m/z*: 546 (M^+), 544 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.56 (3H, t, J = 7.3 Hz, Me), 1.16–1.29 (2H, m, CH_2), 3.22 (3H, s, NMe), 3.72 (2H, t, J = 6.3 Hz, OCH_2), 6.92–8.55 (9H, m, H-Ar), 8.22 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 10.5, 21.8, 26.9, 47.7, 65.2, 75.4, 109.6, 113.6, 115.0, 121.3, 125.3, 126.0, 127.3, 127.5, 127.8, 128.0, 130.5, 130.8, 131.8, 133.9, 135.9, 137.8, 145.4, 154.6, 159.8, 167.8, 178.4, 181.2. Analysis calculated for $C_{28}H_{21}N_2O_5$: C, 61.66; H, 3.88; N, 5.14. Found: C, 61.54; H, 3.79; N, 5.05.

Propyl 10′-amino-5-bromo-1-ethyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5q). Yellow powder (82%); m.p. 290–292°C. IR (KBr) (ν_{max}/cm^{-1}): 3299, 1708, 1675. MS (EI, 70 eV) *m/z*: 560 (M^+), 558 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.51 (3H, t, J = 7.4 Hz, Me), 1.12–1.24 (2H, m, CH_2), 1.31 (3H, t, J = 6.7 Hz, Me), 3.61 (2H, m, NCH_2), 3.84 (2H, m, OCH_2), 6.95–8.55 (9H, m, H-Ar), 8.21 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 10.4, 12.5, 21.8, 35.0, 47.8, 64.9, 75.5, 109.6, 113.4, 115.0, 121.3, 125.3, 126.1, 127.3, 127.6, 127.8, 128.0, 130.5, 130.7, 131.8, 133.9, 135.8, 138.1, 144.6, 154.6, 159.8, 167.8, 177.8, 181.2. Analysis calculated for $C_{29}H_{23}N_2O_5$: C, 62.26; H, 4.14; N, 5.01. Found: C, 62.19; H, 4.09; N, 5.07.

Isopropyl 10′-amino-5-bromo-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5r). Yellow powder (91%); m.p. 294–295°C. IR (KBr) (ν_{max}/cm^{-1}): 3297, 3199, 1719, 1687. MS (EI, 70 eV) *m/z*: 532 (M^+), 530 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.65 (3H, d, J = 6.1 Hz, Me), 1.06 (3H, d, J = 6.1 Hz, Me), 4.70–4.73 (1H, m, OCH), 6.72–8.52 (9H, m, H-Ar), 8.18 (2H, bs, NH_2), 10.52 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 21.2, 21.6, 48.4, 66.6, 76.0, 110.6, 112.6, 115.1, 121.4, 125.3, 126.0, 127.3, 127.6, 127.7, 130.4, 131.8, 133.8, 135.8, 139.2, 144.5, 154.5, 159.6, 167.5, 180.0, 181.2. Analysis calculated for $C_{27}H_{19}BrN_2O_5$: C, 61.03; H, 3.60; N, 5.27. Found: C, 61.11; H, 3.65; N, 5.18.

Isopropyl 10′-amino-5-nitro-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5s). Yellow powder (90%); m.p. 297–299°C. IR (KBr) (ν_{max}/cm^{-1}): 3349, 3272, 1727, 1686. MS (EI, 70 eV) *m/z*: 497 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.63 (3H, d, J = 6.0 Hz, Me), 1.07 (3H, d, J = 6.3 Hz, Me), 4.70–4.74 (1H, m, OCH), 6.98–8.55 (11H, m, H-Ar and NH_2), 11.19 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 21.2, 21.6, 25.9, 48.2, 66.7, 75.4, 108.7, 114.5, 118.9, 121.3, 125.7, 127.3, 127.5, 127.9, 128.1, 130.5, 131.8, 134.0, 135.9, 137.8, 142.0, 151.8, 155.0, 159.8, 167.2, 181.1, 181.4. Analysis calculated for $C_{27}H_{19}N_3O_7$: C, 65.19; H, 3.85; N, 8.45. Found: C, 65.29; H, 3.77; N, 8.52.

Isopropyl 10′-amino-1-methyl-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5t). Yellow powder (85%); m.p. 293–294°C. IR (KBr) (ν_{max}/cm^{-1}): 3249, 1707, 1678. MS (EI, 70 eV) *m/z*: 466 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.59 (3H, d, J = 6.0 Hz, Me), 1.05 (3H, d, J = 6.1 Hz, Me), 3.27 (3H, s, NMe), 4.69–4.73 (1H, m, OCH), 6.81–8.57 (10H, m, H-Ar), 8.10 (2H, s, NH_2). Analysis calculated for $C_{28}H_{22}N_2O_5$: C, 72.09; H, 4.75; N, 6.01. Found: C, 71.98; H, 4.67; N, 5.93. (Due to the very low solubility of product **5t**, we were unable to obtain the ^{13}C-NMR spectrum).

Butyl 10′-amino-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5u). Yellow powder (88%); m.p. 260–262°C. IR (KBr) (ν_{max}/cm^{-1}): 3368, 3255, 1695, 1633. MS (EI, 70 eV) *m/z*: 466 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.75 (3H, t, J = 7.0 Hz, Me), 0.83–1.01 (2H, m, CH_2), 1.21–1.31 (2H, m, CH_2), 3.69–3.85 (2H, m, OCH_2), 6.73–8.53 (10H, m, H-Ar), 8.21 (2H, bs, NH_2), 10.37 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.1, 18.9, 30.2, 48.1, 63.3, 76.4, 108.8, 115.9, 121.0, 121.4, 123.2, 125.3, 127.3, 127.7, 127.8, 130.3, 131.8, 133.6, 135.7, 136.3, 144.8, 154.1, 159.6, 168.2, 180.3, 181.0. Analysis calculated for $C_{28}H_{22}N_2O_5$: C, 72.09; H, 4.75; N, 6.01. Found: C, 71.96; H, 4.68; N, 5.90.

Butyl 10′-amino-5-bromo-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5v). Yellow powder (90%); m.p. 254–256°C. IR (KBr) (ν_{max}/cm^{-1}): 3371, 3261, 1706, 1690. MS (EI, 70 eV) *m/z*: 546 (M^+), 544 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.76 (3H, t, J = 6.9 Hz, Me), 0.83–1.02 (2H, m, CH_2), 1.12–1.32 (2H, m, CH_2), 3.69–3.91 (2H, m, OCH_2), 6.73–8.54 (9H, m, H-Ar), 8.13 (2H, bs, NH_2), 10.53 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.1, 18.9, 30.3, 48.4, 63.3, 75.8, 110.6, 112.7, 115.2, 121.4, 125.3, 126.0, 127.3, 127.6, 127.8, 130.4, 130.5, 131.8, 133.8, 135.8, 138.9, 144.3, 154.5, 159.7, 168.0, 180.0, 181.2. Analysis calculated for $C_{28}H_{21}BrN_2O_5$: C, 61.66; H, 3.88; N, 5.14. Found: C, 61.72; H, 3.80; N, 5.08.

Butyl 10′-amino-5-nitro-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboxylate (5w). Yellow powder (93%); m.p. 251–252°C. IR (KBr) (ν_{max}/cm^{-1}): 3454, 3327, 1733, 1683. MS (EI, 70 eV) *m/z*: 511 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.74 (3H, t, J = 7.1 Hz, Me), 0.85–1.01 (2H, m, CH_2), 1.15–1.30 (2H, m, CH_2), 3.72–3.88 (2H, m, OCH_2), 6.98–8.93 (9H, m, H-Ar), 8.31 (2H, bs, NH_2), 11.20 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.0, 18.9, 30.3, 48.2, 63.4, 75.2, 108.7, 118.9, 121.3, 125.4, 125.7, 127.3, 127.5, 127.8, 128.2, 130.5, 131.8, 134.0, 136.0, 137.6, 142.2, 151.6, 154.9, 159.9, 167.8, 181.0, 181.3. Analysis calculated for $C_{28}H_{21}N_3O_7$: C, 65.75; H, 4.14; N, 8.22. Found: C, 65.83; H, 4.07; N, 8.11.

Pentyl 10′-amino-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho [1,8-*gh*]chromene]-9′-carboperoxoate (5x). Yellow powder (90%); m.p. 238–239°C. IR (KBr) (ν_{max}/cm^{-1}): 3365, 3255, 1684, 1635. MS (EI, 70 eV) *m/z*: 480 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.78(3H, t, J = 7.4 Hz, CH_3), 0.85–1.30 (6H, m, $3CH_2$), 3.66–3.83 (2H, m, OCH_2), 6.74–8.53 (12H, m, H-Ar), 8.13 (2H, bs, NH_2), 10.38 (1H, s, NH) ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.2, 22.3, 27.8, 27.9, 48.1, 63.6, 76.4, 108.8, 115.9, 121.0, 121.4, 123.2, 125.2, 127.3, 127.7, 127.9, 130.3, 131.8, 133.6, 135.7, 136.3, 144.8, 154.1, 159.6, 168.2, 180.3, 181.0. Analysis calculated for $C_{29}H_{24}N_2O_5$: C, 72.49; H, 5.03; N, 5.83. Found: C, 72.55; H, 4.96; N, 5.76.

Pentyl 10′-amino-5-bromo-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboperoxoate (5y). Yellow powder (91%); m.p. 250–252°C. IR (KBr) (ν_{max}/cm^{-1}): 3360, 3277, 1708, 1688. MS (EI, 70 eV) *m/z*: 560 (M^+), 558 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.78–0.83 (5H, m, Me and CH_2), 1.11–1.18 (2H, m, CH_2), 1.21–1.31 (2H, m, CH_2), 3.66–3.81 (2H, m, OCH_2), 6.72–8.53 (9H, m, H-Ar), 8.20 (2H, bs, NH_2), 10.54 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.3, 23.0, 27.9, 28.0, 48.4, 63.3, 75.8, 110.6, 112.8, 115.2, 121.4, 125.3, 126.1, 127.3, 127.6, 127.9, 130.4, 130.5, 131.8, 133.8, 135.8, 138.9, 144.3, 154.5, 160.0, 168.0, 180.0, 181.2. Analysis calculated for $C_{29}H_{23}BrN_2O_5$: C, 62.26; H, 4.14; N, 5.01. Found: C, 62.33; H, 4.23; N, 4.96.

Pentyl 10′-amino-5-nitro-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9’-carboperoxoate (5z). Yellow powder (94%); m.p. 240–242°C. IR (KBr) (ν_{max}/cm^{-1}): 3481, 3332, 1740, 1685. MS (EI, 70 eV) *m/z*: 525 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.73 (5H, t, *J* = 7.3 Hz, Me), 0.81–1.42 (6H, m, $3CH_2$), 3.34–3.71 (2H, m, OCH_2), 6.93–8.57 (9H, m, H-Ar), 8.21 (2H, bs, NH_2), 11.21 (1H, s, NH). Analysis calculated for $C_{29}H_{23}N_3O_7$: C, 66.28; H, 4.41; N, 8.00. Found: C, 66.18; H, 4.34; N, 7.91. (Due to the very low solubility of product **5z**, we were unable to obtain the ^{13}C-NMR spectrum).

2-Methylbutyl 10′-amino-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboperoxoate (5a′). Yellow powder (86%); m.p. 207–209°C. IR (KBr) (ν_{max}/cm^{-1}): 3387, 3299, 1799, 1726. MS (EI, 70 eV) *m/z*: 480 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.54–1.08 (8H, m, 2Me and CH_2), 1.41 (1H, m, CH), 3.62 (2H, m, OCH_2), 6.75–8.51 (10H, m, H-Ar), 8.22 (2H, bs, NH_2), 10.36 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 11.4, 16.5, 25.6, 33.7, 68.0, 68.4, 76.4, 108.9, 116.0, 121.1, 121.3, 123.2, 125.2, 127.3, 127.7, 127.8, 130.3, 131.8, 132.7, 133.6, 135.6, 136.2, 144.6, 154.0, 159.7,168.3, 180.2, 181.0. Analysis calculated for $C_{29}H_{24}N_2O_5$: C, 72.49; H, 5.03; N, 5.83. Found: C, 72.37; H, 5.12; N, 5.71.

2-Methylbutyl 10′-amino-5-bromo-2,7′-dioxo-7′*H*-spiro[indoline-3,8′- naphtho [1,8 - *gh*]chromene] - 9′- carboperoxoate (5b′). Yellow powder (87%); m.p. 256–258°C. IR (KBr) (ν_{max}/cm^{-1}): 3476, 3365, 1720, 1685. MS (EI, 70 eV) *m/z*: 560 (M^+), 558 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.62–0.95 (8H, m, 2Me and CH_2), 1.39 (1H, m, CH), 3.64 (2H, m, OCH_2), 6.73–8.53 (9H, m, H-Ar), 8.20 (2H, bs, NH_2), 10.52 (1H, s, NH). Analysis calculated for $C_{29}H_{23}BrN_2O_5$: C, 62.26; H, 4.14; N, 5.01. Found: C, 62.12; H, 4.06; N, 5.11. (Due to the very low solubility of product **5b′**, we were unable to obtain the ^{13}C-NMR spectrum).

2-Methylbutyl 10′-amino-5-nitro-2,7′-dioxo-7′*H*-spiro[indoline-3,8′-naphtho[1,8-*gh*]chromene]-9′-carboperoxoate (5c′). Yellow powder (89%); m.p. 248–250°C. IR (KBr) (ν_{max}/cm^{-1}): 3327, 1741, 1687. MS (EI, 70 eV) *m/z*: 525 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.51–1.05 (8H, m, 2Me and CH_2), 1.41 (1H, m, CH), 3.67 (2H, m, OCH_2), 6.98–8.55 (9H, m, H-Ar), 8.27 (2H, bs, NH_2), 10.18 (1H, s, NH). Analysis calculated for $C_{29}H_{23}N_3O_7$: C, 66.28; H, 4.41; N, 8.00. Found: C, 66.37; H, 4.47; N, 7.91. (Due to the very low solubility of product **5c′**, we were unable to obtain the ^{13}C-NMR spectrum).

Products **7a**, **7b**, **7e,** and **7l** are known compounds [18] and were characterized by IR and NMR spectroscopic data and their melting points are compared with reported values.

Methyl 2-amino-5’-bromo-1′,7,7-triimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7c). White powder (91%); m.p.: 257–258°C. IR (KBr) (ν_{max}/cm^{-1}): 3251, 3115, 1710, 1701, 1663. MS (EI, 70 eV) *m/z*: 462 (M^+), 460 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.82 (3H, s, Me), 0.93 (3H, s, Me), 1.95 and 2.11 (2H, ABq, *J* = 13.6 Hz, CH_2), 2.31 (2H, bs, CH_2), 3.21 (3H, s, NMe), 3.63 (3H, s, OMe), 6.60 (1H, d, *J* = 8.5 Hz, H-Ar), 7.76 (1H, bs, H-Ar), 7.73 (1H, bs, H-Ar), 7.88 (1H, bs, H-Ar), 8.01 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 27.2, 28.5, 31.5, 36.9, 46.9, 51.2, 65.2, 76.1, 109.9, 113.0, 119.6, 121.8, 127.1, 135.9, 144.0, 158.6, 162.3, 180.1, 195.2. Analysis calculated for $C_{21}H_{21}BrN_2O_5$: C, 54.68; H, 4.59; N, 6.07. Found: C, 54.57; H, 4.52; N, 6.16.

Methyl 2-amino-5′-nitro-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro [chromene-4,3′-indoline]-3-carboxylate (7d). Cream powder (85%); m.p.: 261–263°C. IR (KBr) (ν_{max}/cm^{-1}): 33.87, 3267, 3110, 1714, 1706, 1659. MS (EI, 70 eV) *m/z*: 413 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.91 (3H, s, Me), 1.01 (3H, s, Me), 1.96 and 2.14 (2H, ABq, *J* = 13.3 Hz, CH_2), 2.35 (2H, bs, CH_2), 3.64 (3H, s, OMe), 6.69 (1H, d, *J* = 8.9 Hz, H-Ar), 7.79 (1H, bs, H-Ar), 7.92 (1H, bs, H-Ar), 8.11 (2H, bs, NH_2), 10.93 (1H, bs, NH). Analysis calculated for $C_{20}H_{19}N_3O_7$: C, 58.11; H, 4.63; N, 10.16. Found: C, 58.24; H, 4.54; N, 10.07. (Due to the very low solubility of product **7d**, we were unable to obtain the ^{13}C-NMR spectrum).

Ethyl 2-amino-5′-bromo-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7f). White powder (88%); m.p.: 270–272°C. IR (KBr) (ν_{max}/cm^{-1}): 3368, 3259, 1706, 1698, 1657. MS (EI, 70 eV) *m/z*: 462 (M^+), 460 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.81 (3H, t, *J* = 7.4 Hz, Me), 0.94 (3H, s, Me), 0.98 (3H, s, Me), 1.88 and 1.86 (2H, ABq, *J* = 12.9 Hz, CH_2), 2.37 (2H, bs, CH_2), 3.60–367 (2H, m, OCH_2), 6.64 (1H, d, *J* = 7.8 Hz, H-Ar), 7.56 (1H, bs, H-Ar), 7.64 (1H, bs, H-Ar), 7.92 (2H, bs, NH_2), 10.35 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.1, 27.0, 28.4, 31.9, 45.8, 51.2, 65.4, 76.9, 108.4, 113.4, 119.1, 121.3, 126.3, 135.1, 144.2, 158.2, 161.3, 180.2, 195.1. Analysis calculated for $C_{21}H_{21}BrN_2O_5$: C, 54.68; H, 4.59; N, 6.07. Found: C, 54.60; H, 4.53; N, 5.97.

Ethyl 2-amino-5′-bromo-1′,7,7-trimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene - 4,3′- indoline] -3- carboxylate (7g). White powder (85%); m.p.: 262–263°C. IR (KBr) (ν_{max}/cm^{-1}): 3243, 1708, 1695, 1643. MS (EI, 70 eV) *m/z*: 476 (M^+), 474 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.76 (3H, t, *J* = 7.1 Hz, Me), 0.91 (3H, s, Me), 0.96 (3H, s, Me), 1.91 and 2.08 (2H, ABq, *J* = 13.3 Hz, CH_2), 2.42 (2H, bs, CH_2), 3.33 (3H, s, NMe), 3.62–371 (2H, m, OCH_2), 6.86 (1H, d, *J* = 7.1 Hz, H-Ar), 7.52 (1H, bs, H-Ar), 7.74 (1H, bs, H-Ar), 7.81 (2H, bs, NH_2). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.2, 27.3, 27.9, 32.5, 35.8, 46.7, 51.3, 66.1, 76.3, 109.0, 112.6, 120.3, 121.8, 126.0, 134.7, 143.7, 159.2, 161.8, 179.9, 194.8. Analysis calculated for $C_{22}H_{23}BrN_2O_5$: C, 55.59; H, 4.88; N, 5.89. Found: C, 55.47; H, 4.79; N, 5.78.

Ethyl 2-amino-5′-nitro-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene - 4,3′ - indoline]-3 - carboxylate (7h). Cream powder (89%); m.p.: 280–282°C. IR (KBr) (ν_{max}/cm^{-1}): 34.01, 3267, 1716, 1709, 1663. MS (EI, 70 eV) *m/z*: 427 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.84 (3H, t, *J* = 7.7 Hz, Me), 0.97 (3H, s, Me), 1.11 (3H, s, Me), 1.96 and 2.12 (2H, ABq, *J* = 13.7 Hz, CH_2), 2.45 (2H, bs, CH_2), 3.61–374 (2H, m, OCH_2), 6.91 (1H, d, *J* = 6.8 Hz, H-Ar), 7.63 (1H, bs, H-Ar), 7.86 (1H, bs, H-Ar), 7.90 (2H, bs, NH_2), 11.01 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.5, 27.9, 28.2, 31.7, 46.9, 51.0, 67.3, 77.7, 108.2, 112.9, 121.6, 122.5, 126.3, 135.2, 143.7, 159.7, 161.2, 180.4, 195.3. Analysis calculated for $C_{21}H_{21}N_3O_7$: C, 59.01; H, 4.95; N, 9.83. Found: C, 58.90; H, 4.89; N, 9.78.

Propyl 2-amino-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro [chromene-4,3′-indoline]-3-carboxylate (7i). White powder (87%); m. p.: 232–234°C. IR (KBr) (ν_{max}/cm^{-1}): 3312, 3243, 1715, 1703, 1658. MS (EI, 70 eV) *m/z*: 396 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.52 (3H, bs, Me), 0.91 (3H, s, Me), 0.99 (3H, s, Me), 1.21 (4H, bs, $2CH_2$), 1.98 and 2.14 (2H, ABq, *J* = 14.8 Hz, CH_2), 3.61 (2H, bs, OCH_2), 6.66–7.01 (4H, m, H-Ar), 7.86 (2H, bs, NH_2), 10.12 (1H, s,

NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 10.6, 21.3, 27.1, 28.2, 31.9, 47.0, 51.1, 65.2, 76.8, 108.7, 113.6, 121.0, 122.7, 127.7, 136.3, 144.4, 159.6, 162.8, 168.3, 180.2, 195.1. Analysis calculated for $C_{22}H_{24}N_2O_5$: C, 66.65; H, 6.10; N, 7.07. Found: C, 66.57; H, 6.04; N, 7.17.

Propyl 2-amino-5′-bromo-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7j). White powder (85%); m.p.: 237–239°C. IR (KBr) (ν_{max}/cm^{-1}): 3334, 3254, 1711, 1700, 1644. MS (EI, 70 eV) *m/z*: 476 (M^+), 474 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.55 (3H, bs, Me), 0.95 (3H, s, Me), 0.99 (3H, s, Me), 1.23 (4H, bs, 2CH$_2$), 2.08 (2H, bs, CH$_2$), 3.66 (2H, bs, OCH$_2$), 6.62 (1H, bs, H-Ar), 7.01 (1H, bs, H-Ar), 7.19 (1H, bs, H-Ar), 7.94 (2H, bs, NH$_2$), 10.31 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 10.7, 21.4, 27.5, 27.9, 32.0, 47.3, 51.0, 65.2, 76.1, 110.6, 112.6, 112.9, 125.5, 130.3, 138.9, 143.9, 159.7, 163.3, 168.1, 179.8, 195.3. Analysis calculated for $C_{22}H_{23}BrN_2O_5$: C, 55.59; H, 4.88; N, 5.89. Found: C, 55.49; H, 4.81; N, 5.96.

Propyl 2-amino-5′-nitro-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7k). White powder (83%); m.p.: 241–243°C. IR (KBr) (ν_{max}/cm^{-1}): 3358, 3267, 1719, 1711, 1661. MS (EI, 70 eV) *m/z*: 441 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.54 (3H, t, J = 6.6 Hz, Me), 0.82 (3H, s, Me), 0.95 (3H, s, Me), 1.14–130 (2H, m, CH$_2$), 1.38 and 1.2 (2H, ABq, J = 8.9 Hz, CH$_2$), 2.04–2.10 (2H, m, CH$_2$), 3.65 (2H, m, OCH$_2$), 6.88 (1H, d, J = 8.7 Hz, H-Ar), 7.76 (1H, s, H-Ar), 8.04 (1H, bs, H-Ar), 8.08 (2H, bs, NH$_2$), 10.97 (1H, s, NH). Analysis calculated for $C_{22}H_{23}N_3O_7$: C, 59.86; H, 5.25; N, 9.52. Found: C, 59.77; H, 5.32; N, 10.03.

Isopropyl 2-amino-5′-nitro-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7m). Cream powder (89%); m.p.: 257–258°C. IR (KBr) (ν_{max}/cm^{-1}): 3351, 3276, 1711, 1695, 1643. MS (EI, 70 eV) *m/z*: 441 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.72 (3H, d, J = 6.4 Hz, Me), 0.97 (3H, d, J = 6.2 Hz, Me), 1.01 (3H, s, Me), 1.08 (3H, s, Me), 2.10 (2H, bs, CH$_2$), 2.64 (2H, bs, CH$_2$), 3.76 (1H, m, OCH), 6.88 (1H, d, J = 9.2 Hz, H-Ar), 7.75 (1H, d, J = 2.5 Hz, H-Ar), 8.05 (1H, bs, H-Ar), 8.07 (2H, bs, NH$_2$), 10.97 (1H, s, NH). Analysis calculated for $C_{22}H_{23}N_3O_7$: C, 59.86; H, 5.25; N, 9.52. Found: C, 59.79; H, 5.17; N, 9.47. (Due to the very low solubility of product **7m**, we were unable to obtain the ^{13}C-NMR spectrum).

Isopropyl 2-amino-5′-bromo-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7n). White powder (86%); m.p.: 241–242°C. IR (KBr) (ν_{max}/cm^{-1}): 3334, 3261, 1713, 1702, 1657. MS (EI, 70 eV) *m/z*: 476 (M^+), 474 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.68 (3H, d, J = 6.0 Hz, Me), 0.86 (3H, d, J = 6.4 Hz, Me), 0.92 (3H, s, Me), 1.02 (3H, s, Me), 2.09 (2H, bs, CH$_2$), 2.57 (2H, bs, CH$_2$), 3.70 (1H, m, OCH), 6.62 (1H, bs, H-Ar), 6.99 (1H, s, H-Ar), 7.21 (1H, bs, H-Ar), 7.93 (2H, bs, NH$_2$), 10.29 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.1, 18.8, 27.1, 28.3, 30.1, 31.9, 47.0, 51.1, 63.2, 76.7, 108.7, 113.6, 120.9, 122.6, 127.6, 136.3, 144.3, 159.6, 162.8, 168.3, 180.2, 195.1. Analysis calculated for $C_{22}H_{23}BrN_2O_5$: C, 55.59; H, 4.88; N, 5.89. Found: C, 55.71; H, 4.94; N, 5.80.

Butyl 2-amino-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7o). White powder (88%); m.p.: 227–228°C. IR (KBr) (ν_{max}/cm^{-1}): 3341, 3261, 1714, 1701, 1657. MS (EI, 70 eV) *m/z*: 424 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.73 (3H, t, J = 7.4 Hz, Me), 0.81–0.94 (2H, m, CH$_2$), 0.96 (3H, s, Me), 1.01 (3H, s, Me), 1.18–1.24 (4H, m, 2CH$_2$), 2.52 (2H, bs, CH$_2$), 3.61–3.79 (2H, m, OCH$_2$), 6.78 (1H, d, J = 8.9 Hz, H-Ar), 7.12 (1H, s, H-Ar), 8.04 (1H, s, H-Ar), 8.09 (2H, bs, NH$_2$), 10.67 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.0, 18.6, 27.1, 28.3, 30.3, 32.7, 48.3, 51.1, 63.4, 76.4, 108.4, 112.8, 120.8, 122.1, 127.9, 132.9, 144.3, 159.1, 162.6, 168.7, 180.4, 195.3. Analysis calculated for $C_{23}H_{26}N_2O_5$: C, 67.30; H, 6.38; N, 6.82. Found: C, 67.19; H, 6.32; N, 6.74.

Butyl 2-amino-5′-nitro-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7p). White powder (90%); m.p.: 234–236°C. IR (KBr) (ν_{max}/cm^{-1}): 3356, 3289, 1708, 1687, 1665. MS (EI, 70 eV) *m/z*: 455 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.69 (3H, t, J = 7.0 Hz, Me), 0.83–1.24 (2H, m, CH$_2$), 0.95 (3H, s, Me), 1.06 (3H, s, Me), 1.26–1.29 (4H, m, 2CH$_2$), 2.55 (2H, bs, CH$_2$), 3.67–3.75 (2H, m, OCH$_2$), 6.88 (1H, d, J = 9.1 Hz, H-Ar), 7.76 (1H, s, H-Ar), 8.04 (1H, s, H-Ar), 8.11 (2H, bs, NH$_2$), 10.97 (1H, s, NH). Analysis calculated for $C_{23}H_{25}N_3O_7$: C, 60.65; H, 5.53; N, 9.23. Found: C, 60.74; H, 5.60; N, 9.13.

Butyl 2-amino-7,7-dimethyl-2′,5-dioxo-5,6,7,8-tetrahydrospiro[chromene-4,3′-indoline]-3-carboxylate (7q). White powder (84%); m.p.: 223–225°C. IR (KBr) (ν_{max}/cm^{-1}): 3354, 3271, 1711, 1706, 1645. MS (EI, 70 eV) *m/z*: 410 (M^+). ^{1}H-NMR (300 MHz, DMSO-d_6): δ_H (ppm) 0.76 (3H, t, J = 7.2 Hz, Me), 0.85–1.30 (6H, m, 4CH$_2$), 0.95 (3H, s, Me), 1.03 (3H, s, Me), 2.51 (2H, bs, CH$_2$), 3.62–3.74 (2H, m, OCH$_2$), 6.79 (1H, d, J = 8.1 Hz, H-Ar), 7.17 (1H, s, H-Ar), 8.01 (1H, s, H-Ar), 8.11 (2H, bs, NH$_2$), 10.54 (1H, s, NH). ^{13}C-NMR (75 MHz, DMSO-d_6): δ_C (ppm) 14.3, 19.7, 27.5, 28.3, 30.7, 32.5, 33.1, 48.3, 51.1, 63.4, 76.5, 108.1, 112.9, 121.5, 122.4, 127.6, 133.2, 144.7, 158.7, 162.9, 167.9, 180.1, 195.0. Analysis calculated for $C_{24}H_{28}N_2O_5$: C, 67.91; H, 6.65; N, 6.60. Found: C, 67.88; H, 6.57; N, 6.52.

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