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DIVERSITY-ORIENTED, ONE STEP SYNTHESIS OF CHROMENO[2,3-*b*]INDOLES AND THIOCHROMENO[2,3-*b*]INDOLES UNDER MICROWAVE-ASSISTED CONDITIONS

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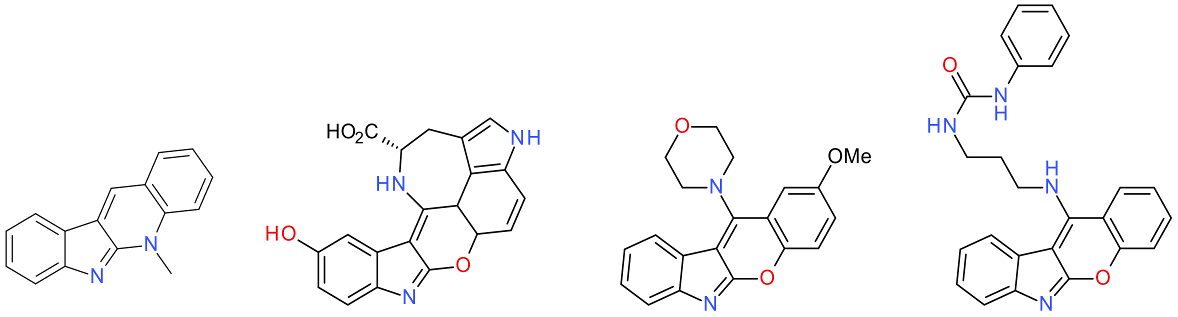
Abstract – A general and efficient synthesis of tetracyclic chromeno[2,3-*b*]indoles, thiochromeno[2,3-*b*]indoles and 6*H*-indolo[2,3-*b*]quinolines has been achieved through a microwave-assisted, metal free, base catalyzed domino Knoevenagel condensation, intramolecular cyclization process starting from simple indoline-2-thiones and 2-substituted benzaldehyde derivatives. This approach provides a straightforward, atom economical and concise route to access a range of otherwise not easily available heterocycles in good yields.

INTRODUCTION

Synthesis of nitrogen, oxygen or sulfur containing functionalized heterocyclic compounds is highly desirable owing to their pharmacological and biological properties. Indoles, quinolines, chromenes, and thiochromenes are important scaffolds found in various biologically active natural products, pharmaceutical drugs, agrochemicals and synthetic compounds. In a similar way, quinoline-fused indoles (indoloquinolines, *e.g.* neocryptolepine, Figure 1.) remain a significant structural framework that is a part of numerous natural products and found to exhibit various activities including antimalarial, cytotoxic, antimuscarinic, antibacterial, antiviral, antimycotic, antihyperglycemic, antitumor and DNA intercalating properties.[1]
Despite the great synthetic attempts that have been devoted toward the synthesis of various indoloquinolines owing to their wide spectrum of biological and pharmacological applications, only limited reports are available in the literature in accessing their oxygen and sulfur analogue versions such as chromeno[2,3-*b*]indoles or thiochromeno[2,3-*b*]indoles. In this paper, we report a new application of the protocol that we developed based on our previous work,[2] which gives rise to a new approach for the synthesis of these heterocycles.
Chromeno[2,3-*b*]indoles are privileged motifs of several natural products[3] and some potential drug molecules, as they were shown as antimalarial[4] and anticancer agents[5] (Figure 1).



neocryptolepine **hyrimomine B** **anticancer agent** **antimalarial compound**

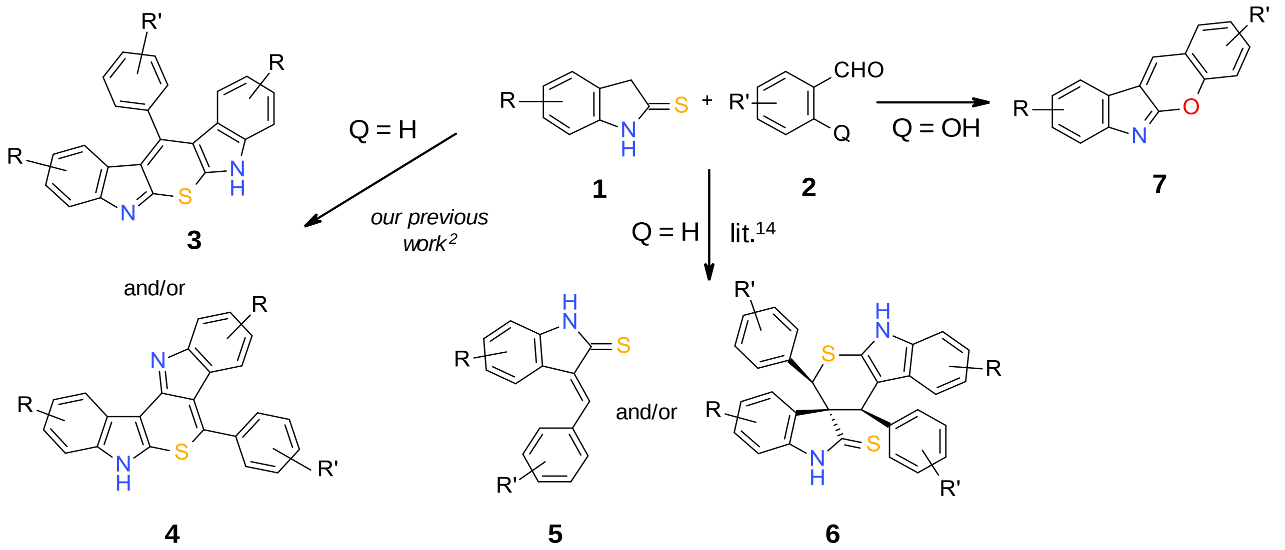
Figure 1. Examples of biologically active compounds containing indoloquinoline and chromeno[2,3-*b*]indole scaffolds

Before the publication of our seminal work[2a] the chromeno[2,3-*b*]indole ring system has been described only as a by-product in a few papers.[6] Since that, several methods for the synthesis of chromeno[2,3-*b*]indole and its derivatives have been reported in the literature.

Most important among those are the one-pot domino approaches which appear to be quite unique in their design. The $Yb(OTf)_3$-catalyzed reaction between 2-alkynylnaphthols and 3-methyleneindolin-2-ones used to produce new, pentacyclic benzo[5,6]chromeno[2,3-*b*]indoles efficiently via an oxidant-free C–C double bond breaking/rearrangement reaction.[7] The reactions between salicylaldehyde and indole resulting in directly the formation of chromeno[2,3-*b*]indole have been described by various groups in refluxing dioxane employing elementary sulfur[8] as promoter and oxidant, via iodine-mediated Friedel-Crafts alkylation/oxidative coupling reaction.[9] Facile one-pot synthesis of chromeno[2,3-*b*]indol-11(6*H*)-one was that published in 2015 by *Zhao et al.*; these authors proposed the one step phenyliodine(III) diacetate mediated intramolecular oxidative annulation of 2-amino-3-phenyl-4*H*-chromen-4-ones (readily prepared from benzyl cyanide with methyl salicylate).[10] Beside these protocols for synthesis of indolo[2,3-*b*]quinolines were described starting from various indole derivatives under the promotion of PPA,[5] TBHP,[11] CuI,[12] or by $Pd(dba)_2$/XantPhos.[13] However, most of these methodologies require higher temperatures or much longer reaction times, sometimes with tedious product isolation procedures, not environment friendly reagents and toxicity of the catalyst or low product yields are additional impediments.

Recently we have described a general and efficient synthesis of 7-aryl-5*H*-thiopyrano[2,3-*b*:4,5-*b*']diindoles **3** and 12-aryl-5*H*-thiopyrano[2,3-*b*:6,5-*b*']diindoles **4** starting from indoline-2-thiones **1** and aromatic aldehydes **2** (Q = H), in simple, one-pot, microwave-assisted reactions.[2b] As a continuation of this study we have investigated the reaction of salicylaldehyde **2** (Q = OH) with indoline-2-thiones **1** under the previously applied standard conditions in microwave reactor at 145 °C. After cooling a single product was isolated by simple filtration from the reaction mixture, which proved to be the known **7** chromeno[2,3-

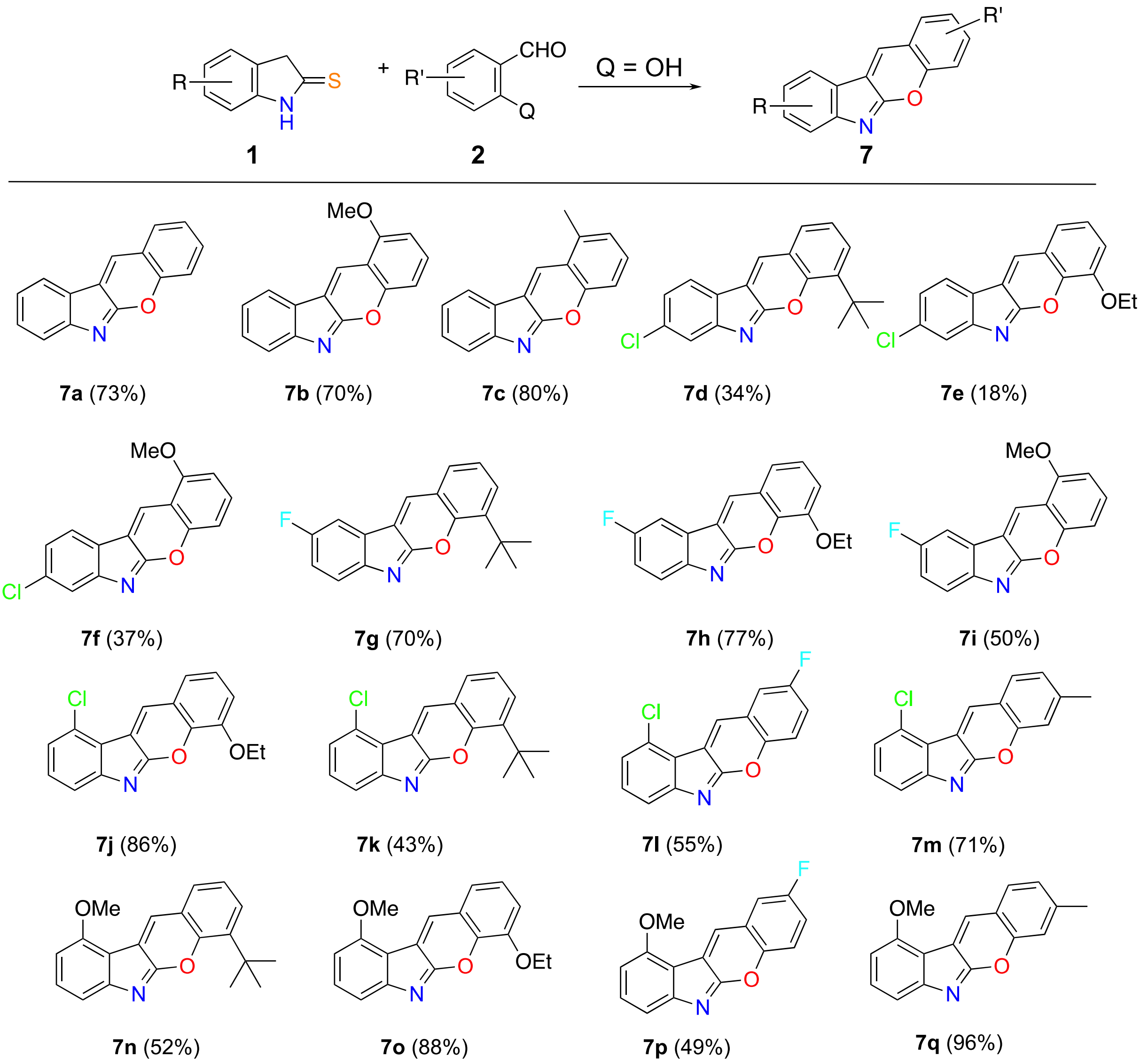
b]indole.[2a] None of the other previously described, potentially possible product types[2b,14] were observed (Scheme 1).



Scheme 1. The reaction of indoline-2-thione **1** and aromatic aldehydes **2**

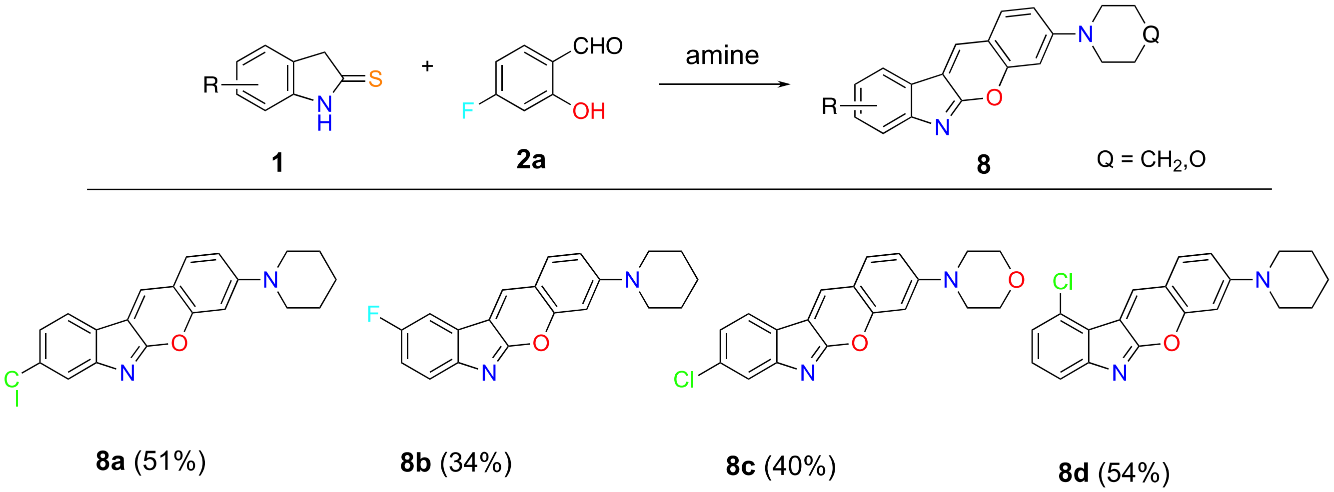
RESULTS AND DISCUSSION

Due to the very clean reaction profile and the easy operating procedure we have investigated the scope and limitations of our initial results using differently substituted indoline-2-thiones **1** and various substituted salicylaldehydes **2** (Q = OH). We have found particularly interesting this reaction as in our earlier study our efforts to optimize the similar reaction of indol-2-one and salicylaldehyde gave only poor yields and a number of by-products.[2a] All the reactions of indoline-2-thiones **1** were run in an *Anton-Paar* microwave reactor at 145 °C, in ethanol in the presence of catalytic amount of piperidine, the products **7a-q** were isolated from the reaction mixtures in most cases after dilution with water by a simple filtration. We have not attempted the further optimization of our previously explored conditions.[2b] The obtained preparative yields were varying from acceptable to good depending on the substituents. As a general rule, the thio-oxindoles with chloro substituents gave lower yields, but in some cases, when the precipitated product was not pure enough the chromatographic purification also decreased the yield. The synthesized compounds and yields are collected in Scheme 2.



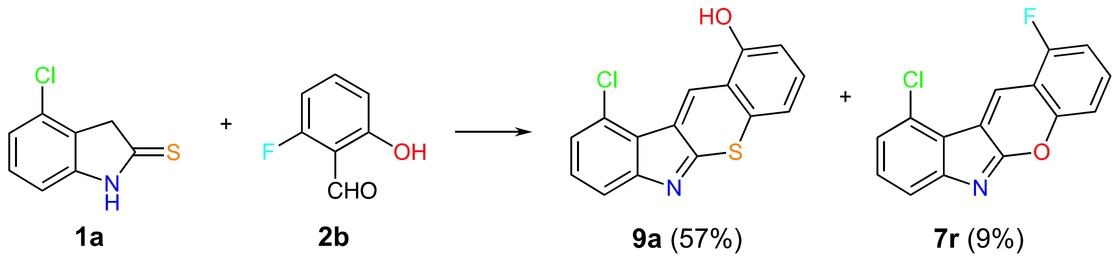
Scheme 2. Reactions of indoline-2-thiones **1** with salicylaldehydes **2** in piperidine/EtOH at 145 ºC in MW

In the reactions of indoline-2-thiones **1** with 4-fluoro-2-hydroxybenzaldehyde **2a** a by-product was observed (lowering the overall yield significantly), which originated from the nucleophilic substitution of the fluorine atom of the aldehyde with the piperidine present in the reaction mixture as a catalyst. When we applied a stoichiometric amount of piperidine or morpholine in the reaction, this by-product become the sole product giving a direct access to the chromeno[2,3-*b*]indol-3-amines **8a-d** via a one step, multicomponent reaction (MCR) in moderate yields after chromatographic purification (Scheme 3). Interesting to note the different reactivity of the fluorine on the indole part of the formed molecule **8b**.



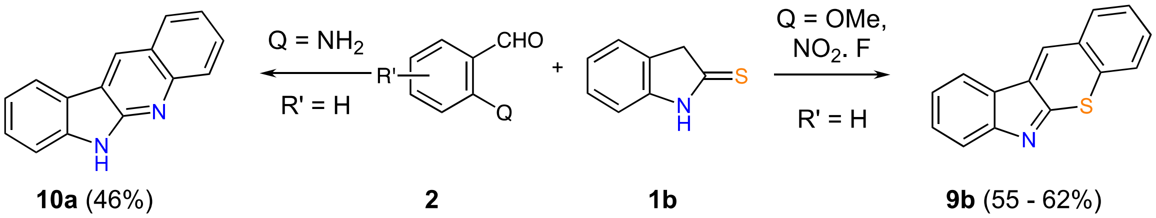
Scheme 3. MCR of indoline-2-thiones with 4-fluoro-2-hydroxybenzaldehyde and amines in EtOH at 145 °C in MW

In the reactions of 4-chloroindoline-2-thione **1a** with 6-fluoro-2-hydroxybenzaldehyde **2b** two products were formed. After the separation and structural identification it become apparent in this reaction the 6:1 mixture of the corresponding thiochromeno[2,3-*b*]indole **9a** and chromeno[2,3-*b*]indole **7r** were formed indicating the relative reactivity of the fluorine and the hydroxy moiety toward the sulfur (Scheme 4). The main product thiochromeno[2,3-*b*]indole is a less frequently described heterocycle compared to its chromeno analogue, only a few methods are described for its preparation in the literature.[15]



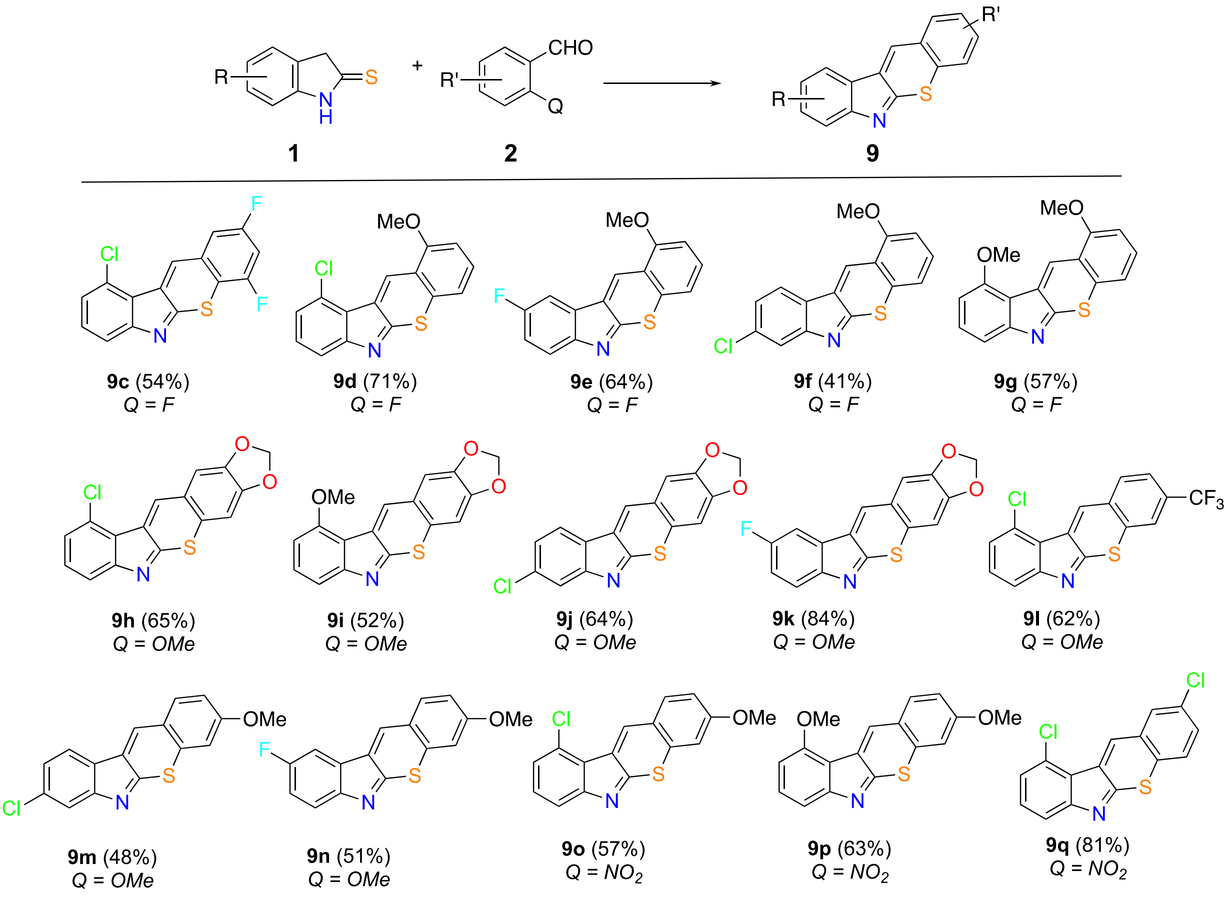
Scheme 4. Reactions of 4-chloroindoline-2-thione **1a** with 6-fluoro-2-hydroxybenzaldehyde **2b** piperidine/EtOH at 145 °C in MW

To further explore the universality of this annulation reaction several 2-substituted-benzaldehydes **2** were reacted with indoline-2-thione **1b**. Using our standard conditions three different substituents (Q = F, OMe, NO_2) were behaving as a leaving group and the same thiochromeno[2,3-*b*]indole **9b** was isolated in all cases, but in different yields, while in the case of 2-aminobenzaldehyde (Q = NH_2) the formation of the norneocryptolepine **10a** was observed as we recently described,[2b] but starting from indolin-2-one. In the case of the use of other aldehydes (e.g. Q = Cl, Br, Me) only complex mixture of products were formed (Scheme 5).



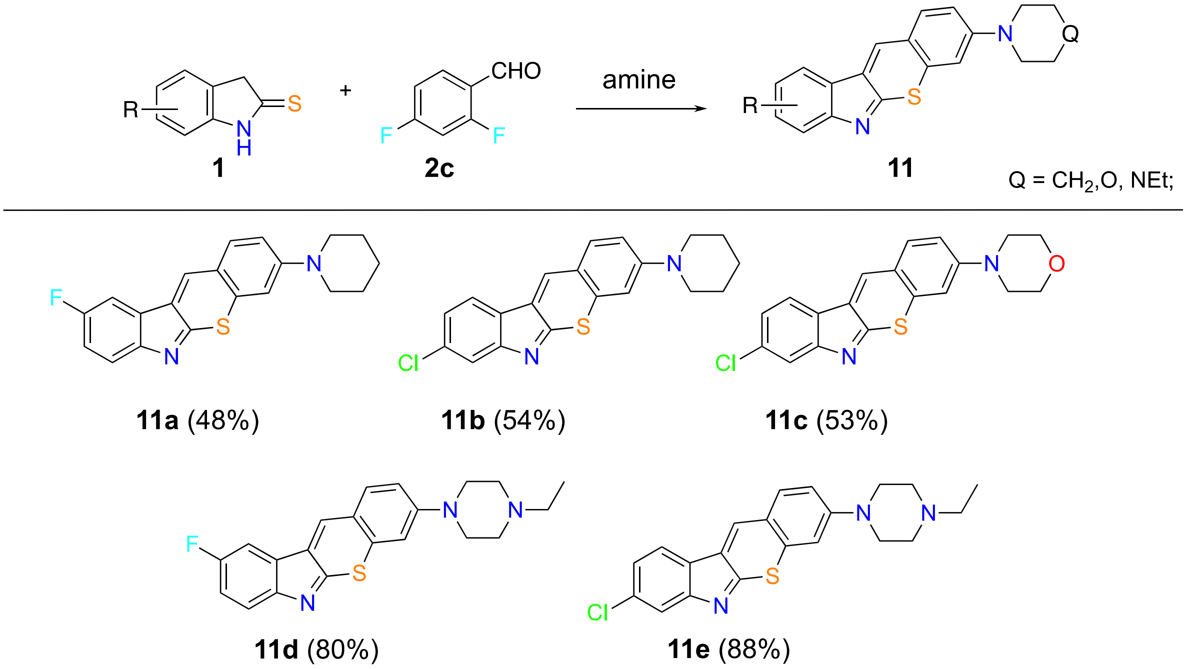
Scheme 5. Reactions of indoline-2-thione with various 2-substituted-benzaldehydes in piperidine/EtOH at 145 ºC in MW

Inspired by these results, we decided on to demonstrate the scope and limitations of this new reaction for the one step synthesis of the thiochromeno[2,3-b]indoles **9**. As it was expected the 2-fluorobenzaldehydes reacted smoothly with indoline-2-thiones bearing some functional groups, but it is remarkable that in the reactions with 2-fluoro-6-methoxybenzaldehyde the methoxy group in all cases remained intact, no competitive reaction was observed. Interestingly, in the absence of the fluorine the 2-methoxy substituents of the aldehydes proceeded well to deliver the corresponding products in 48%–84% yields. The reactions with substituted 2-nitrobenzaldehydes also nicely resulted in the formation of the expected products (Scheme 6).



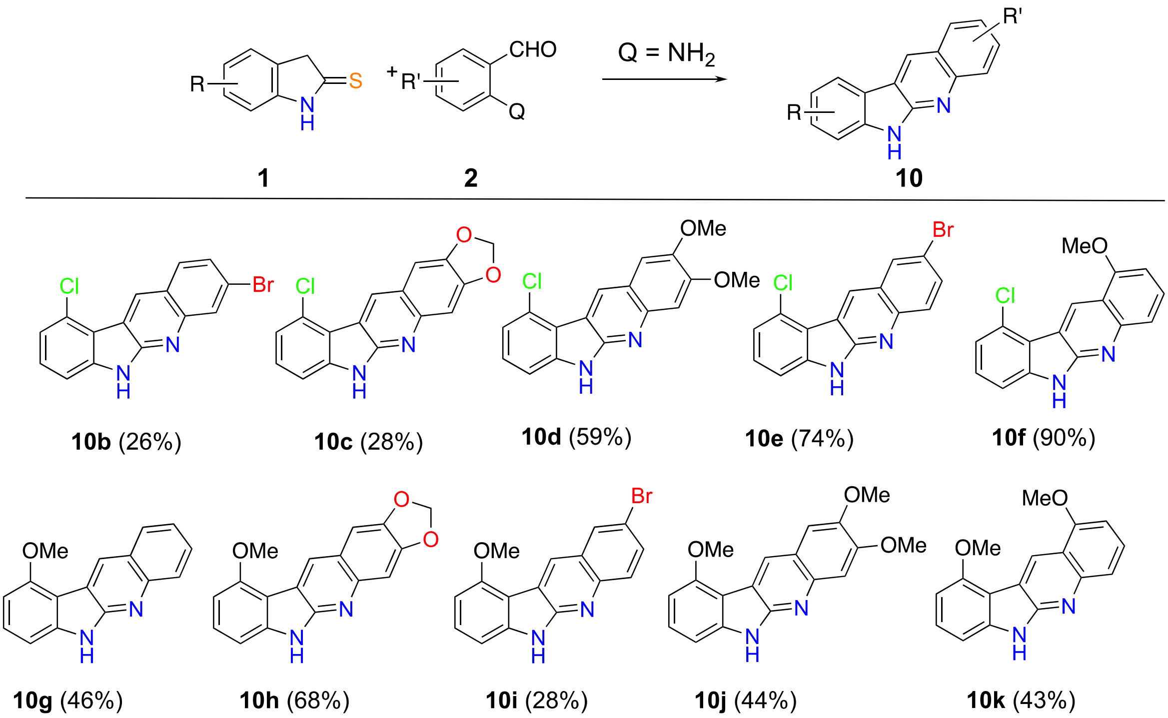
Scheme 6. Reactions of indoline-2-thiones **1** with various 2-substituted-benzaldehydes **2** in piperidine/EtOH at 145 ºC in MW

Similarly to the reactions of indoline-2-thione with 4-fluoro-2-hydroxybenzaldehyde in the presence of the stochiometric amount of amines the interaction of 2,4-difluorobenzaldehyde with indoline-2-thiones reacted again in a multicomponent reaction manner and the formation of thiochromeno[2,3-*b*]indol-3-amines **11a-e** were observed in good yields (Scheme 7).



Scheme 7. MCR of indoline-2-thiones **1** with 2,4-difluorobenzaldehyde **2c** and amines in EtOH at 145 ºC in MW

Finally, we have prepared a small library of new, variously substituted norneocryptolepine derivatives **10a-k** using the observed reaction of 2-aminobenzaldehydes and indoline-2-thiones. With some exceptions in general all reaction gave a low to medium yields using our standard conditions in the microwave reactor, leading to the conclusion, that our recently published procedure[2b] superior, both in yields and the accessibility of the potential starting materials. From the mechanistic standpoint important to see that in the reaction of 2-amino-6-methoxybenzaldehyde again the methoxy group remained intact in the reaction, no thiochromeno[2,3-*b*]indole was observed in the reaction mixture (Scheme 8).



Scheme 8. Reactions of indoline-2-thiones with various 2-aminobenzaldehydes in piperidine/EtOH at 145 ºC in MW

The mechanism of this kind of domino Knoevenagel condensation/intramolecular ring closure has been described earlier by us.[2] Based on these new experimental results the following tentative reaction route was proposed (Figure 2). The intermediate formed in the Knoevenagel condensation in its correct isomeric form deprotonated at the applied high temperature by the action of base present in the reaction mixture. In the cases when this proton removed from the Q substituent (Q = OH or NH_2) cyclization took place by the intramolecular nucleophilic attack on the indolinone thiocarbonyl group, followed by a H_2S elimination resulting in finally the formation of the most stable fully aromatic heterocyclic system.

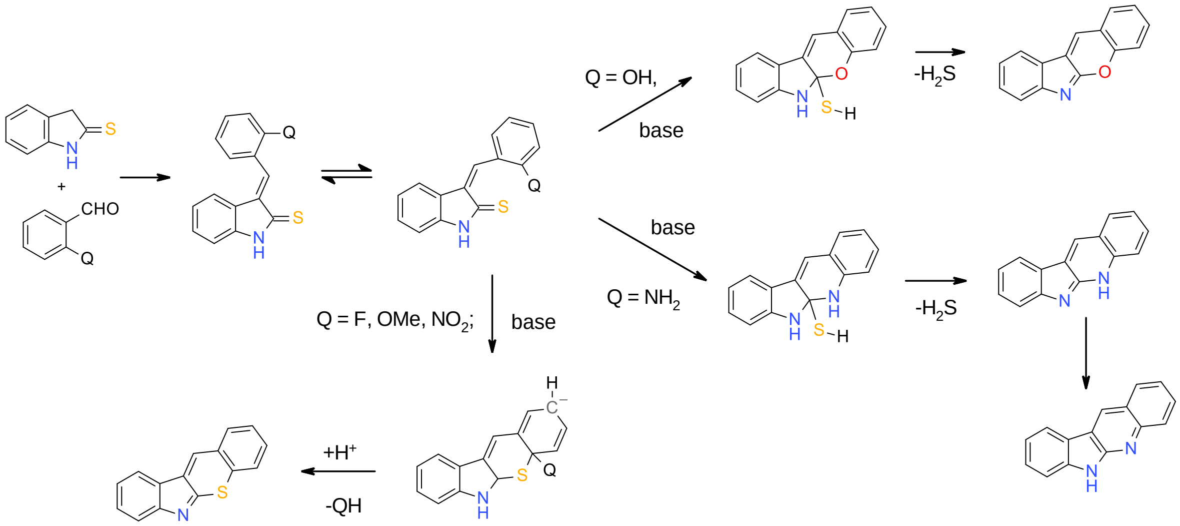


Figure 2. Proposed reaction mechanism

In the cases when this proton was only available on the indoline-2-thione part, the formed anion initiated the nucleophilic substitution of the eliminating Q group (R = F, OMe, NO_2). The nucleophilic substitution of the fluorine is well known and often used strategy in the organic synthesis, however for similar replacements of the aromatic methoxy- and nitro groups there are only some scattered examples.[16]

In conclusion, we have provided a one-pot preparation of structurally diverse linear tetracycles such as chromeno[2,3-*b*]indoles, thiochromeno[2,3-*b*]indoles and indolo[2,3-*b*]quinolines by sequential Knoevenagel condensation, intramolecular cyclization process starting from simple thio-oxindoles and 2-substituted-benzaldheydes under microwave conditions.

EXPERIMENTAL

The starting materials were purchased from commercial sources. The known thio-oxindoles (**1**) were prepared by using a literature method.[17] IR spectra were recorded with a Bruker Tensor 27 FT-IR spectrophotometer. All ^{1}H-, ^{13}C-NMR spectra were recorded in DMSO-*d₆* with a Bruker Avance III. spectrometer operating at 500 MHz and 125 MHz respectively (^{1}H-, ^{13}C-, DEPTQ-, HSQC-, HMBC-NMR). *Due to the very low solubility of some of the products not all the quaternary carbons have been successfully detected. They are not visible in the ^{13}C-NMR spectrum due to the dynamic processes taking place in the molecule. Prototropic tautomerism may also be the reason of the broadening and complete disappearance of some carbon resonance.* High-resolution MS spectra were measured by Agilent 6230 TOF LC/MS spectrometer. All reagents and solvents were purchased and used without further purification.

General procedure: The corresponding indoline-2-thione (1 mmol) and aromatic aldehyde (1.1 mmol) was dissolved in EtOH (4 mL) catalytic piperidine (0.05 mL, 0.5 mmol) or the appropriate stochiometric amine (1.1 mmol) was added. The reaction mixture was irradiated in an *Anton-Paar* microwave reactor for 30 min at 145 °C. After cooling the mixture was diluted with water (4 mL) and the formed precipitate was collected by filtration, washed with cold EtOH and dried in *vacuo* to yield the title products. If the isolated material was not pure enough (>95% HPLC purity) the residue was further purified by column chromatography (heptane → heptane/EtOAc 1:2, gradient).

[1]Benzopyrano[2,3-*b*]indole (7a): yellow powder (161 mg, 73%); identical with the earlier described example.[2a]

1-Methoxy[1]benzopyrano[2,3-*b*]indole (7b): orange powder (175 mg, 70%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.92 (s, 1H, H-11), 8.18 (d, 1H, J = 7.6 Hz, H-10), 7.73 (t, 1H, J = 8.3 Hz, H-3), 7.56 (d, 1H, J = 7.6 Hz, H-7), 7.49 (t, 1H, J = 7.6 Hz, H-8), 7.39 (d, 1H, J = 8.3 Hz, H-4), 7.28 (t, 1H, J = 7.6 Hz, H-9), 7.14 (d, 1H, J = 8.3 Hz, H-2), 4.05 (s, 3H, *O*CH_3); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 164.2 (q), 157.1 (q), 152.6 (q), 152.2 (q), 133.2 (CH), 129.9 (CH), 126.3 (CH), 124.2 (q), 123.9 (q), 122.7 (2 x CH), 119.0 (CH), 110.2 (q), 110.3 (CH), 106.6 (CH), 56.9 (*O*CH$_3$); IR (KBr, cm^{-1}): 1650, 1609, 1546, 1435, 1263, 1194, 1084. HRMS [M+H]$^+$ found = 250.0864; C$_{16}$H$_{11}$NO$_2$ required 250.0868.

1-Methyl[1]benzopyrano[2,3-*b*]indole (7c): orange powder (187 mg, 80%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 9.02 (s, 1H, H-11), 8.17 (d, 1H, *J* = 7.6 Hz, H-10), 7.69 – 7.63 (m, 2H, H-4 and H-3), 7.59 – 7.55 (m, 1H, H-7), 7.51 (td, 1H, *J* = 7.6 and 1.2 Hz, H-8), 7.42 – 7.38 (m, 1H, H-2), 7.31 (td, 1H, *J* = 7.6 and 1.2 Hz, H-9), 2.76 (s, 3H, CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 164.3 (q), 152.9 (q), 152.0 (q), 138.3 (q), 132.1 (CH), 130.1 (CH), 129.3 (CH), 126.3 (CH), 124.8 (q), 124.3 (q), 122.7 (CH), 122.6 (CH), 119.1 (CH), 118.6 (q), 115.8 (CH), 19.1 (CH$_3$); IR (KBr, cm^{-1}): 1653, 1612, 1545, 1446, 1435, 1423, 1192. HRMS [M+H]$^+$ found = 234.0915; C$_{16}$H$_{11}$NO required 234.0919.

4-*tert*-Butyl-8-chloro[1]benzopyrano[2,3-*b*]indole (7d): purified by column chromatography, tan powder (105 mg, 34%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.89 (s, 1H, H-11), 8.08 (d, 1H, *J* = 8.0 Hz, H-10), 7.91 (d, 1H, *J* = 7.6 Hz, H-1), 7.76 (d, 1H, *J* = 7.6 Hz, H-3), 7.62 (s, 1H, H-7), 7.50 (t, 1H, *J* = 7.6 Hz, H-2), 7.34 (d, 1H, *J* = 8.0 Hz, H-9) 1.57 (s, 9H, *t*Bu); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 165.0 (q), 154.1 (q), 150.1 (q), 138.2 (q), 134.2 (CH), 134.1 (q), 130.4 (CH), 129.1 (CH), 125.1 (CH), 123.8 (CH), 123.3 (q), 122.6 (CH), 122.6 (q), 120.1 (q), 119.0 (CH), 35.4 (q), 30.2 (3 x CH$_3$); IR (KBr, cm^{-1}): 2971, 1658, 1541, 1433, 1060. HRMS [M+H]$^+$ found = 310.0993; C$_{19}$H$_{16}$ClNO required 310.0998.

8-Chloro-4-ethoxy[1]benzopyrano[2,3-*b*]indole (7e): purified by column chromatography, red powder (53 mg, 18%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.83 (s, 1H, H-11), 8.06 (d, 1H, *J* = 8.0 Hz, H-10), 7.60 (s, 1H, H-7), 7.53 (d, 1H, *J* = 7.0 Hz, H-1), 7.47 (d, 1H, *J* = 7.0 Hz, H-3), 7.44 (t, 1H, *J* = 7.0 Hz, H-2), 7.32 (d, 1H, *J* = 8.0 Hz, H-9), 4.27 (q, 2H, *J* = 6.9 Hz, *O*CH$_2$), 1.48 (t, 3H, *J* = 6.9 Hz, CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 165.3 (q), 154.1 (q), 147.3 (q), 141.1 (q), 134.4 (q), 133.3 (CH), 125.3 (CH), 124.3 (q), 123.8 (CH), 122.6 (CH), 122.6 (q), 121.5 (CH), 120.4 (q), 119.1 (CH), 115.9 (CH), 65.1 (*O*CH$_2$), 15.1 (CH$_3$); IR (KBr, cm^{-1}): 1609, 1546, 1446, 1379, 1284, 1060. HRMS [M+H]$^+$ found = 298.0632; C$_{17}$H$_{12}$ClNO$_2$ required 298.0635.

8-Chloro-1-methoxy[1]benzopyrano[2,3-*b*]indole (7f): orange powder (105 mg, 37%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.95 (s, 1H, H-11), 8.17 (d, 1H, *J* = 8.0 Hz, H-10), 7.73 (t, 1H, *J* = 8.3 Hz, H-3), 7.57 (d, 1H, *J* = 1.7 Hz, H-7), 7.37 (d, 1H, *J* = 8.3 Hz, H-4), 7.29 (dd, 1H, *J* = 8.0 and 1.7 Hz, H-9), 7.12 (d, 1H, *J* = 8.3 Hz, H-2), 4.03 (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 165.1 (q), 157.2 (q), 153.8 (q), 152.2 (q), 134.0 (q), 133.6 (CH), 127.6 (CH), 123.9 (CH), 123.0 (q), 122.8 (q), 122.5 (CH), 118.9 (CH), 110.3 (q), 110.0 (CH), 106.7 (CH), 56.9 (*O*CH$_3$); IR (KBr, cm^{-1}): 1643, 1609, 1552, 1444, 1278, 1194, 1058. HRMS [M+H]$^+$ found = 284.0476; C$_{16}$H$_{10}$ClNO$_2$ required 284.0478.

4-*tert*-Butyl-9-fluoro[1]benzopyrano[2,3-*b*]indole (7g): red powder (205 mg, 70%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.87 (s, 1H, H-11), 7.96 (dd, 1H, *J* = 8.5 and 2.7 Hz, H-10), 7.90 (dd, 1H, *J* = 7.8 and 1.5 Hz, H-1), 7.77 (dd, 1H, *J* = 7.8 and 1.5 Hz, H-3), 7.57 (dd, 1H, *J* = 8.5 and 4.5 Hz, H-7), 7.50 (t, 1H, *J* = 7.8

Hz, H-2), 7.35 (td, 1H, *J* = 8.5 and 2.7 Hz, H-8) 1.57 (s, 9H, *t*Bu); ^{19}F-NMR (376 MHz, DMSO-*d*$_6$): δ -120.53 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 165.0 (q), 158.8 (q, $^1J_{CF}$ = 239.1Hz), 150.3 (q), 149.1 (q), 138.2 (q), 134.6 (CH), 130.5 (CH), 129.2 (CH), 124.9 (CH), 124.7 (q), 124.1 (q), 120.0 (CH), 119.8 (q), 116.9 (CH), 109.4 (CH), 35.4 (q), 30.2 (3 x CH_3); IR (KBr, cm^{-1}): 2971, 1655, 1429, 1398, 1234, 1153, 1082. HRMS [M+H]$^+$ found = 294.1290; $C_{19}H_{16}FNO$ required 294.1294.

4-Ethoxy-9-fluoro[1]benzopyrano[2,3-*b*]indole (7h): red powder (217 mg, 77%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.85 (s, 1H, H-11), 7.95 (dd, 1H, *J* = 8.1 and 2.7 Hz, H-10), 7.60 – 7.52 (m, 2H, H-7 and H-1), 7.51 – 7.47 (m, 1H, H-3), 7.46 (t, 1H, *J* = 7.8 Hz, H-2), 7.35 (t, 1H, *J* = 9.0 Hz, H-8), 4.29 (q, 2H, *J* = 6.8 Hz, *O*CH_2) 1.48 (t, 3H, *J* = 6.8 Hz, CH_3); ^{19}F-NMR (376 MHz, DMSO-*d*$_6$): δ -120.46 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 133.9 (CH), 125.2 (CH), 121.6 (CH), 120.6 (CH), 116.9 (CH), 116.1 (CH), 109.4 (CH), 65.1 (*O*CH_2), 15.2 (CH_3); IR (KBr, cm^{-1}): 1656, 1545, 1446, 1388, 1274, 1178, 1111, 1091. HRMS [M+H]$^+$ found = 282.0926; $C_{17}H_{12}FNO_2$ required 282.0930.

9-Fluoro-1-methoxy[1]benzopyrano[2,3-*b*]indole (7i): orange powder (130 mg, 50%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 9.03 (s, 1H, H-11), 8.10 (dd, 1H, *J* = 8.8 and 2.8 Hz, H-10), 7.75 (t, 1H, *J* = 8.3 Hz, H-3), 7.55 (dd, 1H, *J* = 8.8 and 4.5 Hz, H-7), 7.39 (d, 1H, *J* = 8.3 Hz, H-4), 7.33 – 7.28 (m, 1H, H-8), 7.15 (dd, 1H, *J* = 8.3 and 0.7 Hz, H-2), 4.05 (s, 3H, *O*CH_3); ^{19}F-NMR (376 MHz, DMSO-*d*$_6$): δ -120.45 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 164.1 (q), 158.8 (q), 157.3 (q), 152.4 (q), 148.8 (q), 133.7 (CH), 128.1 (CH), 125.2 (q), 123.7 (q), 119.9 (CH), 116.6 (CH), 110.1 (CH), 110.1 (q), 109.6 (CH) 106.7 (CH), 57.0 (*O*CH_3); IR (KBr, cm^{-1}): 1650, 1545, 1475. 1429. 1276, 1259, 1177, 1085. HRMS [M+H]$^+$ found = 268.0769; $C_{16}H_{10}FNO_2$ required 268.0774.

10-Chloro-4-ethoxy[1]benzopyrano[2,3-*b*]indole (7j): orange powder (256 mg, 86%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.96 (s, 1H, H-11), 7.72 (dd, 1H, *J* = 7.8 and 1.2 Hz, H-1), 7.59 (d, 1H, *J* = 7.6 Hz, H-7), 7.54 (t, 1H, *J* = 7.6 Hz, H-8), 7.52 (dd, 1H, *J* = 7.8 Hz and 1.2 Hz, H-3), 7.48 (t, 1H, *J* = 7.8 Hz, H-2), 7.36 (d, 1H, *J* = 7.6 Hz, H-9), 4.30 (q, 2H, *J* = 7.0 Hz, *O*CH_2), 1.49 (t, 3H, *J* = 7.0 Hz, CH_3); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 164.3 (q), 154.2 (q), 147.3 (q), 141.0 (q), 135.2 (CH), 131.1 (CH), 128.7 (q), 125.3 (CH), 123.7 (q), 123.2 (CH), 121.9 (CH), 121.2 (q), 120.4 (q), 118.2 (CH), 116.3 (CH), 65.1 (*O*CH_2), 116.3 (CH_3); IR (KBr, cm^{-1}): 1552, 1452, 1390, 1282, 1230, 1112, 1099. HRMS [M+H]$^+$ found = 298.0632; $C_{17}H_{12}ClNO_2$ required 298.0635.

4-*tert*-Butyl-10-chloro[1]benzopyrano[2,3-*b*]indole (7k): red powder (133 mg, 43%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.95 (s, 1H, H-11), 8.05 (dd, 1H, *J* = 7.7 and 1.4 Hz, H-1), 7.77 (dd, 1H, *J* = 7.7 and 1.4 Hz, H-3), 7.57 (dd, 1H, *J* = 7.8 and 1.0 Hz, H-9), 7.53 (t, 1H, *J* = 7.8 Hz, H-8), 7.50 (t, 1H, *J* = 7.7 Hz, H-2), 7.33 (dd, 1H, *J* = 7.8 and 1.0 Hz, H-7), 1.57 (s, 9H, *t*Bu); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 164.0 (q), 154.2 (q), 150.0 (q), 138.1 (q), 135.8 (CH), 131.0 (CH), 130.8 (CH), 129.6 (CH), 128.6 (q), 125.0 (CH), 123.1 (CH), 122.6 (q), 121.2 (q), 120.0 (q), 118.1 (CH), 35.4 (q), 30.2 (3 x CH_3); IR (KBr, cm^{-1}): 1601, 1454, 1418, 1385, 1342, 1325, 1269, 1234, 1192, 1171, 1132, 1099; HRMS $[M+H]^+$ found = 310.0994; $C_{19}H_{16}ClNO$ required 310.0998.

10-Chloro-2-fluoro[1]benzopyrano[2,3-*b*]indole (7l): red powder (149 mg, 55%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.95 (s, 1H, H-11), 8.07 (dd, 1H, J = 8.8 and 3.1 Hz, H-1), 7.91 (dd, 1H, J = 8.8 and 4.5 Hz, H-4), 7.74 – 7.67 (m, 1H, H-3), 7.58 (dd, 1H, J = 7.8 and 1.2 Hz, H-7), 7.55 (t, 1H, J = 7.8 Hz, H-8), 7.36 (dd, 1H, J = 7.8 and 1.2 Hz, H-9); ^{19}F-NMR (376 MHz, DMSO-d_6): δ -117.21 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 164.5 (q), 158.6 (q, $^1J_{CF}$ = 237.80 Hz), 154.3 (q), 147.8 (q), 133.9 (CH), 131.5 (CH), 128.9 (q), 124.6 (q), 123.4 (CH), 121.0 (q), 120.8 (q), 120.5 (CH), 119.8 (CH), 118.3 (CH), 115.7 (CH); IR (KBr, cm^{-1}): 1647, 1547, 1446, 1402, 1381, 1285, 1226, 1145, 1132; HRMS $[M+H]^+$ found = 272.0275; $C_{15}H_7ClFNO$ required 272.0278.

10-Chloro-3-methyl[1]benzopyrano[2,3-*b*]indole (7m): orange powder (190 mg, 71%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.97 (s, 1H, H-11), 8.07 (d, 1H, J = 7.8 Hz, H-1), 7.70 (s, 1H, H-4), 7.58 (dd, 1H, J = 7.8 and 1.0 Hz, H-7), 7.53 (t, 1H, J = 7.8 Hz, H-8), 7.41 (d, 1H, J = 7.8 Hz, H-2), 7.35 (dd, 1H, J = 7.8 and 1.0 Hz, H-9), 2.54 (s, 3H, CH_3); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 164.5 (q), 153.8 (q), 151.7 (q), 144.6 (q), 135.2 (CH), 130.8 (CH), 130.6 (CH), 128.5 (q), 126.7 (CH), 123.1 (CH), 122.6 (q), 121.4 (q), 118.2 (CH), 117.8 (CH), 117.5 (q), 21.9 (CH_3); IR (KBr, cm^{-1}): 1608, 1546, 1392, 1226, 1192, 1132. HRMS $[M+H]^+$ found = 268.0526; $C_{16}H_{10}ClNO$ required 268.0529.

4-*tert*-Butyl-10-methoxy[1]benzopyrano[2,3-*b*]indole (7n): orange powder (159 mg, 52%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.55 (s, 1 H, H-11), 7.97 (dd, 1H, J = 7.8 and 1.5 Hz, H-1), 7.71 (dd, 1H, J = 7.8 and 1.5 Hz, H-3), 7.50 (t, 1H, J = 7.8 Hz, H-8), 7.46 (t, 1H, J = 7.8 Hz, H-2), 7.20 (dd, 1H, J = 7.8 and 0.5 Hz, H-7), 6.96 (dd, 1H, J = 7.8 and 0.5 Hz, H-9), 4.05 (s, 3H, *O*CH_3), 1.57 (s, 9H, *t*Bu); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 163.8 (q), 156.6 (q), 154.1 (CH), 149.6 (CH), 138.0 (q), 132.9 (CH), 131.5 (CH), 129.6 (q), 128.9 (q), 124.8 (CH), 123.0 (q), 120.5 (q), 112.3 (CH), 111.3 (q), 105.6 (CH), 56.2 (CH_3), 35.4 (q), 30.2 (3 x CH_3); IR (KBr, cm^{-1}): 1543, 1424, 1338, 1269, 1087; HRMS $[M+H]^+$ found = 306.1491; $C_{20}H_{19}NO_2$required 306.1494.

4-Ethoxy-10-methoxy[1]benzopyrano[2,3-*b*]indole (7o): red powder (258 mg, 88%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.50 (s, 1H, H-11), 7.62 (dd, 1H, J = 7.0 and 2.7 Hz, H-1), 7.49 (t, 1H, J = 8.0 Hz, H-8), 7.45 – 7.39 (m, 2H, H-3 and H-2), 7.20 (d, 1H, J = 8.0 Hz, H-7), 6.95 (d, 1H, J = 8.0 Hz, H-9), 4.27 (q, 2H, J = 7.0 Hz, *O*CH_2), 4.04 (s, 3H, *O*CH_3), 1.48 (t, 3H, J = 7.0 Hz, CH_3); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 164.1 (q), 156.6 (q), 153.9 (q), 147.2 (q), 140.6 (q), 132.1 (CH), 131.6 (CH), 124.9 (CH), 124.0 (q), 121.3 (CH), 120.8 (q), 115.2 (CH), 112.4 (CH), 111.3 (q), 105.6 (CH), 65.0 (*O*CH_2), 56.2 (*O*CH_3) 15.2 (CH_3); IR (KBr, cm^{-1}): 1545, 1390, 1276, 1226, 1085. HRMS $[M+H]^+$ found = 294.1126; $C_{18}H_{15}NO_3$ required 294.1130.

2-Fluoro-10-methoxy[1]benzopyrano[2,3-*b*]indole (7p): red powder (131 mg, 49%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.51 (s, 1H, H-11), 7.99 (dd, 1H, *J* = 8.7 and 3.0 Hz, H-1), 7.86 (dd, 1H, *J* = 8.7 and 4.5 Hz, H-4), 7.62 (td, 1H, *J* = 8.7 and 3.0 Hz, H-3), 7.50 (t, 1H, *J* = 8.0 Hz, H-8), 7.20 (d, 1H, *J* = 8.0 Hz, H-9), 6.97 (d, 1H, *J* = 8.0 Hz, H-7), 4.05 (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 164.3 (q), 158.6 (q, $^1J_{CF}$ = 241.1 Hz), 156.8 (q), 154.1 (q), 147.4 (q), 132.1 (CH), 130.9 (CH), 124.9 (q), 121.3 (q), 119.6 (CH), 119.3 (CH), 115.1 (CH), 112.5 (CH), 111.1 (q), 105.9 (CH), 56.2 (*O*CH$_3$); IR (KBr, cm^{-1}): 1612, 1550, 1410, 1278, 1224, 1084. HRMS [M+H]$^+$ found = 268.0770; $C_{16}H_{10}FNO_2$ required 268.0774.

10-Methoxy-3-methyl[1]benzopyrano[2,3-*b*]indole (7q): orange powder (253 mg, 96%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.48 (s, 1H, H-11), 7.95 (d, 1H, *J* = 7.9 Hz, H-1), 7.62 (s, 1H, H-4), 7.46 (t, 1H, *J* = 8.0 Hz, H-8), 7.33 (d, 1H, *J* = 7.9 Hz, H-2), 7.19 (d, 1H, *J* = 8.0 Hz, H-7), 6.93 (d, 1H, *J* = 8.0 Hz, H-9), 4.03 (s, 3H, *O*CH$_3$), 2.50 (s, 3H, CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 164.3 (q), 156.4 (q), 151.2 (q), 143.1 (q), 133.7 (q), 132.2 (CH), 131.2 (CH), 129.8 (CH), 126.3 (CH), 123.1 (q), 117.9 (q), 117.7 (CH), 112.4 (CH), 111.6 (q), 105.5 (CH), 56.1 (*O*CH$_3$), 21.8 (CH$_3$); IR (KBr, cm^{-1}): 1611, 1539, 1491, 1394, 1269, 1087. HRMS [M+H]$^+$ found = 264.1021; $C_{17}H_{13}NO_2$ required 264.1024.

10-Chloro-1-fluoro[1]benzopyrano[2,3-*b*]indole (7r): isolated by column chromatography from the reaction in Scheme 4, orange powder (19 mg, 9%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.72 (s, 1H, H-11), 7.90 – 7.81 (m, 1H, H-3), 7.73 (d, 1H, *J* = 8.5 Hz, H-4), 7.60 (dd, 1H, *J* = 7.8 and 1.0 Hz, H-9), 7.57 (t, 1H, *J* = 7.8 Hz, H-8), 7.47 (t, 1H, *J* = 8.5 Hz, H-2), 7.38 (dd, 1H, *J* = 7.8 and 1.0 Hz, H-7); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 163.9 (q), 159.0 (q, $^1J_{CF}$ = 254.7 Hz), 154.0 (q), 151.8 (q), 133.7 (CH), 131.7 (CH), 129.0 (q),

126.0 (CH), 124.2 (q), 123.7 (CH), 121.1 (q), 118.4 (CH), 114.2 (CH), 111.3 (CH), 109.8 (q); IR (KBr, cm^{-1}): 1649, 1620, 1556, 1452, 1402, 1195, 1026. HRMS [M+H]$^+$ found = 272.0275; $C_{15}H_7ClFNO$ required 272.0278.

8-Chloro-3-(piperidin-1-yl)[1]benzopyrano[2,3-*b*]indole (8a): brown powder (171 mg, 51%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.63 (s, 1H, H-11), 7.94 (d, 1H, *J* = 8.1 Hz, H-10), 7.76 (d, 1H, *J* = 8.8 Hz, H-1), 7.53 (d, 1H, *J* = 1.9 Hz, H-7), 7.24 (dd, 1H, *J* = 8.1 and 1.9 Hz, H-9), 7.17 (d, 1H, *J* = 2.4 Hz, H-4), 7.14 (dd, 1H, *J* = 8.8 and 2.4 Hz, H-2), 3.55 – 3.49 (m, 4H, Pip-6' and 2'H), 1.70 – 1.60 (m, 6H, Pip-5', 4' and 3'H); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 166.0 (q), 154.4 (q), 153.1 (q), 143.4 (q), 133.8 (CH), 132.4 (q), 131.2 (CH), 125.0 (q), 123.3 (q), 122.3 (CH), 121.8 (CH), 118.4 (CH), 112.4 (CH), 110.3 (q), 100.4 (CH), 48.5 (2 x *N*CH$_2$), 25.4 (2 x CH$_2$), 24.3 (CH$_2$); IR (KBr, cm^{-1}): 2935, 1614, 1392, 1201, 1121, 1118, 1053. HRMS [M+H]$^+$ found = 337.1103; $C_{20}H_{17}ClN_2O$ required 337.1107.

9-Fluoro-3-(piperidin-1-yl)[1]benzopyrano[2,3-*b*]indole (8b): brown powder (109 mg, 34%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.65 (s, 1H, H-11), 7.80 (dd, 1H, *J* = 8.7 and 2.7 Hz, H-10), 7.74 (d, 1H, *J* = 8.9 Hz, H-1), 7.49 (dd, 1H, *J* = 8.7 and 4.6 Hz, H-7), 7.23 – 7.17 (m, 2H, H-8 and H-4), 7.14 (dd, 1H, *J* = 8.9

and 2.4 Hz, H-2), 3.55 – 3.48 (m, 4H, Pip-6’ and 2’H), 1.68 – 1.57 (m, 6H, Pip-5’, 4’ and 3’H); ^{19}F-NMR (376 MHz, DMSO-d_6): δ -121.50 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 164.8 (q), 158.5 (q), 154.8 (q), 154.1 (q), 147.7 (q), 134.3 (CH), 131.4 (CH), 125.4 (q), 119.6 (CH), 118.9 (q), 114.9 (CH), 112.2 (CH), 109.9 (q), 107.8 (CH), 100.4 (CH), 48.4 (2 x *N*CH$_2$), 25.4 (2 x CH$_2$), 24.4 (CH$_2$); IR (KBr, cm^{-1}): 2933, 1621, 1537, 1518, 1415, 1211, 1118. HRMS [M+H]$^+$ found = 321.1399; $C_{20}H_{17}FN_2O$ required 321.1403.

8-Chloro-3-(morpholin-4-yl)[1]benzopyrano[2,3-*b*]indole (8c): orange powder (135 mg, 40%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.68 (s, 1H, H-11), 7.97 (d, 1H, *J* = 8.1 Hz, H-10), 7.82 (d, 1H, *J* = 8.9 Hz, H-1), 7.55 (d, 1H, *J* = 1.8 Hz, H-7), 7.26 (dd, 1H, *J* = 8.1 and 1.8 Hz, H-9), 7.23 (d, 1H, *J* = 2.3 Hz, H-4), 7.17 (dd, 1H, *J* = 8.9 and 2.3 Hz, H-2), 3.78 (t, 4H, *J* = 4.7 Hz, Mor-6’ and 2’H), 3.46 (t, 4H, *J* = 4.7 Hz, Mor-5’ and 3’H); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 165.8 (q), 154.2 (q), 154.1 (q), 153.0 (q), 133.6 (CH), 132.7 (q), 131.1 (CH), 123.3 (q), 122.5 (CH), 122.0 (CH), 119.3 (q), 118.8 (CH), 112.3 (CH), 111.3 (q), 101.0 (CH), 66.3 (2 x *O*CH$_2$), 47.5 (2 x *N*CH$_2$); IR (KBr, cm^{-1}): 1608, 1597, 1533, 1444, 1371, 1192, 1060. HRMS [M+H]$^+$ found = 339.0897; $C_{19}H_{15}ClN_2O_2$ required 339.0904.

10-Chloro-3-(piperidin-1-yl)[1]benzopyrano[2,3-*b*]indole (8d): orange powder (181 mg, 54%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.73 (s, 1H, H-11), 7.87 (d, 1H, *J* = 8.0 Hz, H-1), 7.50 (d, 1H, *J* = 8.0 Hz, H-7), 7.40 (t, 1H, *J* = 8.0 Hz, H-8), 7.24 (d, 1H, *J* = 8.0 Hz, H-9), 7.18 – 7.10 (m, 2H, H-4 and H-2), 3.58 – 3.46 (m, 4H, Pip-6’ and 2’H), 1.71 – 1.57 (m, 6H, Pip-5’, 4’ and 3’H); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 164.8 (q), 154.7 (q), 154.4 (q), 152.9 (q), 135.6 (CH), 131.7 (CH), 128.8 (CH), 127.5 (q), 122.2 (CH), 121.9 (q), 117.8 (CH), 117.6 (q), 112.4 (CH), 110.4 (q), 100.2 (CH), 48.4 (2 x *N*CH$_2$), 25.4 (2 x CH$_2$), 24.4 (CH$_2$); IR (KBr, cm^{-1}): 1608, 1597, 1533, 1400, 1242, 1193, 1128. HRMS [M+H]$^+$ found = 337.1104; $C_{20}H_{17}ClN_2O$ required 337.1107.

10-Chloro[1]benzothiopyrano[2,3-*b*]indol-1-ol (9a): isolated by column chromatography from the reaction in Scheme 4;. orange powder (125 mg, 57%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 11.37 (s, 1H, OH), 9.48 (s, 1H, H-11), 7.66 (dd, 1H, *J* = 7.8 and 0.8 Hz, H-7), 7.62 (t, 1H, *J* = 8.0 Hz, H-3), 7.56 (t, 1H, *J* = 7.8 Hz, H-8), 7.53 (d, 1H, *J* = 8.0 Hz, H-4), 7.40 (dd, 1H, *J* = 7.8 and 0.8 Hz, H-9), 7.12 (dd, 1H, *J* = 8.0 and 1.0 Hz, H-2); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 161.8 (q), 158.6 (q), 156.2 (q), 133.6 (q), 133.1 (CH), 130.3 (CH), 130.2 (CH), 128.4 (q), 127.8 (q), 123.6 (CH), 123.0 (q), 117.8 (CH), 117.7 (CH), 115.9 (q), 112.6 (CH); IR (KBr, cm^{-1}): 2500, 1612, 1583, 1444, 1323, 1271, 1201, 1134. HRMS [M+H]$^+$ found = 286.0089; $C_{15}H_8ClNOS$ required 286.0093.

[1]Benzothiopyrano[2,3-*b*]indole (9b): yellow powder; identical with the earlier described examples.[15]

10-Chloro-2,4-difluoro[1]benzothiopyrano[2,3-*b*]indole (9c): red powder (164 mg, 54%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 9.12 (s, 1H, H-11), 8.21 (dd, 1H, *J* = 9.3 and 1.7 Hz, H-1), 7.88 (td, 1H, *J* = 11.0 and 2.7 Hz, H-3), 7.65 (dd, 1H, *J* = 7.9 and 0.7 Hz, H-7), 7.59 (t, 1H, *J* = 7.9 H, H-8), 7.41 (dd, 1H, *J* = 7.9 and 0.7 Hz, H-9); ^{19}F-NMR (376 MHz, DMSO-d_6): δ -110.91 (s, 1F), -110.82 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 160.4 (q, $^1J_{CF}$ = 233.20 Hz), 160.1 (q), 157.5 (q, $^1J_{CF}$ = 233.20 Hz) 156.4 (q), 134.5 (CH), 131.6 (CH), 131.2 (q), 129.3 (q), 129.1 (q), 124.3 (CH), 122.1 (q), 118.0 (CH), 116.1 (CH), 115.6 (q), 107.0 (CH); IR (KBr, cm^{-1}): 1601, 1454, 1418, 1385, 1342, 1325, 1269, 1234, 1192, 1171, 1132, 1099; HRMS [M+H]$^+$ found = 305.9952; $C_{15}H_6ClF_2NS$ required 305.9956.

10-Chloro-1-methoxy[1]benzothiopyrano[2,3-*b*]indole (9d): red powder (213 mg, 71%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 9.48 (s, 1H, H-11), 7.78 (t, 1H, *J* = 8.2 Hz, H-3), 7.69 (dd, 1H, *J* = 8.2 and 0.7 Hz, H-4), 7.68 (dd, 1H, *J* = 7.8 and 0.8 Hz, H-7), 7.58 (t, 1H, *J* = 7.8 Hz, H-8), 7.42 (dd, 1H, *J* = 7.8 and 0.8 Hz, H-9), 7.30 (d, 1H, *J* = 8.2 Hz, H-2), 4.09 (s, 3 H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 161.5 (q), 159.1 (q), 156.3 (q), 133.8 (q), 133.1 (CH), 130.5 (CH), 129.3 (CH), 128.6 (2 x q), 123.7 (CH), 122.8 (q), 119.4 (CH), 117.8 (CH), 116.7 (q), 108.9 (CH), 57.1 (*O*CH$_3$); IR (KBr, cm^{-1}): 1600, 1469, 1433, 1389, 1356, 1325, 1263, 1207, 1040; HRMS [M+H]$^+$ found = 300.0247; $C_{16}H_{10}ClNOS$ required 300.0250.

9-Fluoro-1-methoxy[1]benzothiopyrano[2,3-*b*]indole (9e): red powder (181 mg, 64%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 9.25 (s, 1H, H-11), 8.26 (dd, 1H, *J* = 8.8 and 2.6 Hz, H-10), 7.74 (t, 1H, *J* = 8.1 Hz, H-3), 7.65 – 7.61 (m, 2H, H-7 and H-4), 7.39 – 7.33 (m, 1H, H-8), 7.26 (dd, 1H, *J* = 8.1 and 0.8 Hz, H-2), 4.08 (s, 3H, *O*CH$_3$); ^{19}F-NMR (376 MHz, DMSO-d_6): δ -120.38 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 160.5 (q), 159.1(q) 159.0 (q), 151.2 (q), 134.3 (q), 132.6 (CH), 129.7 (q), 128.0 (CH), 127.7 (q), 119.3 (CH), 119.1 (CH), 116.6 (q), 116.5 (CH), 109.1 (CH), 108.8 (CH), 56.9 (*O*CH$_3$); IR (KBr, cm^{-1}): 1626, 1587, 1456, 1404, 1356, 1263,1173,1039. HRMS [M+H]$^+$ found = 284.0540; $C_{16}H_{10}FNOS$ required 284.0545.

8-Chloro-1-methoxy[1]benzothiopyrano[2,3-*b*]indole (9f): orange powder (123 mg, 41%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 9.17 (s, 1H, H-11), 8.32 (d, 1H, *J* = 8.1 Hz, H-10), 7.72 (t, 1H, *J* = 8.1 Hz, H-3), 7.67 (d, 1H, *J* = 1.8 Hz, H-7), 7.63 (d, 1H, *J* = 8.1 Hz, H-4), 7.34 (dd, 1H, *J* = 8.1 and 1.8 Hz, H-9), 7.25 (d, 1H, *J* = 8.1 Hz, H-2), 4.07 (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 162.4 (q), 159.0 (q), 155.7 (q), 133.9 (q), 133.8 (q), 132.5 (CH), 128.9 (q), 127.4 (CH), 125.3 (q), 123.3 (CH), 122.6 (CH), 119.4 (CH), 118.3 (CH), 116.9 (q), 108.8 (CH), 56.9 (*O*CH$_3$); IR (KBr, cm^{-1}): 1593, 1552, 1458, 1429, 1400, 1347, 1259, 1192, 1045; HRMS [M+H]$^+$ found = 300.0245; $C_{16}H_{10}ClNOS$ required 300.0250.

1,10-Dimethoxy[1]benzothiopyrano[2,3-*b*]indole (9g): orange powder (130 mg, 57%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 9.09 (s, 1H, H-11), 7.70 (t, 1H, *J* = 8.1 Hz, H-3), 7.62 (d, 1H, *J* = 8.1 Hz, H-4), 7.52 (t, 1H, *J* = 8.0 Hz, H-8), 7.29 (dd, 1H, *J* = 8.0 and 0.5 Hz, H-7), 7.25 (dd, 1H, *J* = 8.1 and 0.8 Hz, H-2), 7.01 (d, 1H, *J* = 8.0 Hz, H-9), 4.09 (s, 3H, 10-*O*CH$_3$), 4.07 (s, 3H, 1-*O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 160.5 (q), 158.6 (q), 156.9 (q), 156.1 (q), 133.1 (q), 131.8 (CH), 130.9 (CH), 129.2 (CH), 127.1 (q), 119.3 (CH), 117.2 (q), 113.7 (q), 111.8 (CH), 108.5 (CH), 105.6 (CH), 56.9 (*O*CH$_3$), 56.4 (*O*CH$_3$); IR (KBr, cm^{-1}): 1621, 1603, 1548, 1448, 1398, 1350, 1264, 1084, 1035. HRMS [M+H]$^+$ found = 296.0745; $C_{17}H_{13}NO_2S$ required 296.0742.

10-Chloro-2*H*-[1,3]dioxolo[6,7][1]benzothiopyrano[2,3-*b*]indole (9h): red powder (204 mg, 65%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 9.18 (s, 1H, H-11), 7.97 (s, 1H, H-12), 7.83 (s, 1H, H-4), 7.65 (dd, 1H, *J* = 7.9 and 0.9 Hz, H-7), 7.55 (t, 1H, *J* = 7.9 Hz, H-8), 7.38 (dd, 1H, *J* = 7.9 and 0.9 Hz, H-9), 6.30 (s, 2H, CH$_2$); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 161.0 (q), 155.8 (q), 151.4 (q), 147.9 (q), 136.5 (CH), 129.9 (CH), 129.2 (q), 128.3 (q), 127.4 (q), 123.0 (CH), 122.5 (q), 122.0 (q), 117.4 (CH), 111.8 (CH), 106.4 (CH), 103.5 (CH$_2$); IR (KBr, cm^{-1}): 1602, 1485, 1458, 1437, 1383, 1342, 1265, 1228, 1193, 1174, 1103, 1043, 1028; HRMS [M+H]$^+$ found = 314.0039; $C_{16}H_8ClNO_2S$ required 314.0042.

10-Methoxy-2*H*-[1,3]dioxolo[6,7][1]benzothiopyrano[2,3-*b*]indole (9i): red powder (161 mg, 52%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.74 (s, 1H, H-11), 7.82 (s, 1H, H-12), 7.74 (s, 1H, H-4), 7.49 (t, 1H, *J* = 8.0 Hz, H-8), 7.26 (d, 1H, *J* = 8.0 Hz, H-7), 6.96 (d, 1H, *J* = 8.0 Hz, H-9), 6.26 (s, 2H, CH$_2$), 4.07 (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 160.3 (q), 156.7 (q), 155.9 (q), 150.5 (q), 147.7 (q), 134.4 (CH), 130.4 (CH), 128.1 (q), 127.9 (q), 122.3 (q), 113.5 (q), 111.6 (CH), 111.2 (CH), 106.4 (CH), 104.9 (CH), 103.2 (CH$_2$), 56.2 (*O*CH$_3$): IR (KBr, cm^{-1}): 1595, 1450, 1394, 1340, 1242, 1178, 1082, 1024; HRMS [M+H]$^+$ found = 310.0534; $C_{17}H_{11}NO_3S$ required 310.0538.

8-Chloro-2*H*-[1,3]dioxolo[6,7][1]benzothiopyrano[2,3-*b*]indole (9j): red powder (200 mg, 64%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.97 (s, 1H, H-11), 8.17 (d, 1H, *J* = 7.8 Hz, H-10), 7.82 (s, 1H, H-4), 7.71 (s, 1H, H-12), 7.69 (d, 1H, *J* = 1.5 Hz, H-7), 7.36 (d, 1H, *J* = 7.8 Hz, H-9), 6.29 (s, 2H, CH$_2$); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 162.1 (q), 155.5 (q), 151.2 (q), 147.9 (q), 134.4 (CH), 133.4 (q), 129.3 (q), 127.9 (q), 124.9 (q), 122.6 (CH), 122.2 (CH), 121.9 (q), 118.3 (CH), 111.1 (CH), 106.7 (CH), 103.5 (CH$_2$); IR (KBr, cm^{-1}): 2918, 1589, 1500, 1475, 1392, 1365, 1251, 1213, 1035. HRMS [M+H]$^+$ found = 314.0038; $C_{16}H_8ClNO_2S$ required 314.0042.

9-Fluoro-2*H*-[1,3]dioxolo[6,7][1]benzothiopyrano[2,3-*b*]indole (9k): red powder (223 mg, 84%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 8.95 (s, 1H, H-11), 8.01 (dd, 1H, *J* = 8.7 and 2.5 Hz, H-10), 7.80 (s, 1H, H-4), 7.67 (s, 1H, H-12), 7.64 (dd, 1H, *J* = 8.7 and 4.5 Hz, H-7), 7.36 (td, 1H, *J* = 8.7 and 2.5 Hz, H-8), 6.29 (s, 2H, CH$_2$); ^{19}F-NMR (376 MHz, DMSO-d_6): δ -120.99 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 160.2 (q), 158.8 (q), 151.2 (q), 150.0 (q), 147.9 (q), 134.8 (CH), 129.5 (q), 127.2 (q), 121.6 (q), 121.5 (q), 119.3 (CH), 116.3 (CH), 111.2 (CH), 108.1 (CH), 106.7 (CH), 103.5 (CH$_2$); IR (KBr, cm^{-1}): 3022, 1620, 1504, 1475, 1400, 1254, 1217, 1173, 1040. HRMS [M+H]$^+$ found = 298.0334; $C_{16}H_8FNO_2S$ required 298.0338.

10-Chloro-3-(trifluoromethyl)[1]benzothiopyrano[2,3-*b*]indole (9l): red powder (209 mg, 62%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 9.23 (s, 1H, H-11), 8.60 (s, 1H, H-4), 8.56 (d, 1H, *J* = 8.2 Hz, H-1), 7.97 (dd, 1H, *J* = 8.2 and 1.5 Hz, H-2), 7.67 (dd, 1H, *J* = 7.8 and 0.7 Hz, H-7), 7.60 (t, 1H, *J* = 7.8 Hz, H-8), 7.42 (dd, 1H, *J* = 7.8 and 0.7 Hz, H-9); ^{19}F-NMR (376 MHz, DMSO-d_6): δ -61.01 (s, CF$_3$), ^{13}C-NMR (125 MHz, DMSO-d_6): δ 161.9 (q), 156.5 (q), 135.3 (CH), 135.0 (CH), 133.0 (q), 131.5 (CH), 131.3 (q), 130.5 (q, $^{1}J_{CF}$ = 33.69 Hz), 129.7 (q), 129.4 (q), 124.6 (CH), 124.2 (CH), 124.2 (q, $^{1}J_{CF}$ = 273.33 Hz), 123.4 (CH), 122.4 (q), 117.9 (CH); IR (KBr, cm^{-1}): 1599, 1456, 1413, 1390, 1359, 1313, 1276, 1232, 1168, 1124, 1132, 1082; HRMS [M+H]$^+$ found = 338.0016; $C_{16}H_7ClF_3NS$ required 338.0018.

8-Chloro-3-methoxy[1]benzothiopyrano[2,3-*b*]indole (9m): red powder (144 mg, 48%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 9.01 (s, 1H, H-11), 8.17 (d, 1H, *J* = 7.9 Hz, H-10), 8.12 (d, 1H, *J* = 8.8 Hz, H-1), 7.75 (d, 1H, *J* = 2.1 Hz, H-4), 7.69 (d, 1H, *J* = 1.5 Hz, H-7), 7.37 (dd, 1H, *J* = 7.9 and 1.5 Hz, H-9), 7.31 (dd, 1H, *J* = 8.8 and 2.1 Hz, H-2), 3.96 (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 161.1 (q), 155.4 (q), 133.7 (q), 135.4 (CH), 134.8 (CH), 127.5 (q), 125.3 (q), 122.5 (2 x CH), 122.4 (q), 120.5 (q), 118.3 (CH), 116.3 (CH), 110.7 (CH), 56.6 (*O*CH$_3$); IR (KBr, cm^{-1}): 2987, 1595, 1433, 1338, 1274, 1234, 1062. HRMS [M+H]$^+$ found = 300.0245; $C_{16}H_{10}ClNOS$ required 300.0250.

9-Fluoro-3-methoxy[1]benzothiopyrano[2,3-*b*]indole (9n): red powder (144 mg, 51%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.97 (s, 1H, H-11), 8.07 (d, 1H, *J* = 8.7 Hz, H-1), 8.01 (dd, 1H, *J* = 8.7 and 2.6 Hz, H-10), 7.71 (d, 1H, *J* = 2.5 Hz, H-4), 7.62 (dd, 1H, *J* = 8.7 and 4.6 Hz, H-7), 7.37 – 7.31 (m, 1H, H-8), 7.28 (dd, 1H, *J* = 8.7 and 2.5 Hz, H-2), 3.95 (s, 3H, *O*CH$_3$); ^{19}F-NMR (376 MHz, DMSO-*d*$_6$): δ -120.96 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 161.6 (q), 160.4(q) 158.9 (q, $^1J_{CF}$ = 239.9 Hz), 150.9 (q), 136.1 (q), 135.4 (CH), 135.0 (CH), 128.2 (q), 127.7 (q), 120.2 (q), 119.3 (CH), 116.1 (CH), 116.0 (CH), 110.8 (CH), 108.1 (CH), 56.6 (*O*CH$_3$); IR (KBr, cm^{-1}): 2978, 1596, 1460, 1338, 1271, 1205, 1174, 1109. HRMS [M+H]$^+$ found = 284.0542; $C_{16}H_{10}FNOS$ required 284.0545.

10-Chloro-3-methoxy[1]benzothiopyrano[2,3-b]indole (9o): red powder (171 mg, 57%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 9.08 (s, 1H, H-11), 8.24 (d, 1H, *J* = 8.8 Hz, H-1), 7.66 (d, 1H, *J* = 2.4 Hz, H-4), 7.62 (dd, 1H, *J* = 7.8 and 0.7 Hz, H-7), 7.51 (t, 1H, *J* = 7.8 Hz, H-8), 7.34 (dd, 1H, *J* = 7.8 and 0.7 Hz, H-9), 7.26 (dd, 1H, *J* = 8.8 and 2.4 Hz, H-2), 3.96 (s, 3 H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 161.9 (q), 161.4 (q), 156.0 (q), 136.6 (CH), 136.1 (CH), 135.7 (q), 129.7 (CH), 128.3 (q), 127.3 (q), 123.3 (CH), 123.1 (q), 120.6 (q), 117.6 (CH), 116.0 (CH), 110.8 (CH), 56.6 (*O*CH$_3$); IR (KBr, cm^{-1}): 1591, 1529, 1492, 1454, 1392, 1336, 1280, 1242, 1192, 1190, 1128, 1064, 1012; HRMS [M+H]$^+$ found = 300.0246; $C_{16}H_{10}ClNOS$ required 300.0250.

3,10-Dimethoxy[1]benzothiopyrano[2,3-*b*]indole (9p): red powder (186 mg, 63%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.75 (s, 1H, H-11), 8.18 (d, 1H, *J* = 8.8 Hz, H-1), 7.68 (d, 1H, *J* = 2.5 Hz, H-4), 7.48 (t, 1H, *J* = 8.0 Hz, H-8), 7.28-7.24 (m, 1H, H-7), 7.25 (dd, 1H, *J* = 8.8 and 2.5 Hz, H-2), 6.97 (d, 1H, *J* = 8.0 Hz, H-9), 4.07 (s, 3H, 10-*O*CH$_3$), 3.94 (s, 3H, 3-*O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 161.0 (q), 160.4 (q), 156.6 (q), 155.7 (q), 135.1 (CH), 134.7 (q), 134.5 (CH), 130.2 (CH), 127.7 (q), 120.9 (q), 115.9 (CH), 113.7 (q), 111.7 (CH), 110.5 (CH), 105.3 (CH), 56.5 (*O*CH$_3$), 56.1 (*O*CH$_3$): IR (KBr, cm^{-1}): 1595, 1450, 1394, 1340, 1242, 1178, 1082, 1024; HRMS [M+H]$^+$ found = 296.0739; $C_{17}H_{13}NO_2S$ required 296.0745.

2,10-Dichloro[1]benzothiopyrano[2,3-*b*]indole (9q): red powder (175 mg, 81%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 9.24 (s, 1H, H-11), 8.59 (d, 1H, *J* = 2.4 Hz, H-1), 8.18 (d, 1H, *J* = 8.6 Hz, H-4), 7.85 (dd, 1H, *J* = 8.6 and 2.4 Hz, H-3), 7.69 (dd, 1H, *J* = 7.8 and 0.8 Hz, H-7), 7.61 (t, 1H, *J* = 7.8 Hz, H-8), 7.44 (dd, 1H, *J* = 7.8 and 0.8 Hz, H-9); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 161.8 (q), 156.4 (q), 135.2 (CH), 133.3 (CH), 131.7 (q), 131.2 (CH), 131.0 (CH), 131.0 (q), 130.3 (q), 129.1 (q), 129.1 (CH), 128.3 (q), 124.0 (CH), 122.5 (q), 117.8 (CH); IR (KBr, cm^{-1}): 1601, 1454, 1418, 1385, 1342, 1325, 1269, 1234, 1192, 1171, 1132, 1099; HRMS [M+H]$^+$ found = 303.9749; $C_{15}H_7Cl_2NS$required 303.9754.

6*H*-Indolo[2,3-*b*]quinoline (10a): yellow powder; identical with the earlier described examples.[2b]

3-Bromo-10-chloro-6*H*-indolo[2,3-*b*]quinoline (10b): orange powder (85 mg, 26%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 12.23 (s, 1H, NH), 9.32 (s, 1H, H-11), 8.22 (d, 1H, *J* = 8.9 Hz, H-1), 8.19 (d, 1H, *J* = 1.9 Hz, H-4), 7.64 (dd, 1H, *J* = 8.9 and 1.9 Hz, H-2), 7.57 (t, 1H, *J* = 8.0 Hz, H-8), 7.50 (dd, 1H, *J* = 8.0 and 0.9 Hz, H-7), 7.35 (dd, 1H, *J* = 8.0 and 0.9 Hz, H-9); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 153.5 (q), 147.4 (q), 142.0 (q), 131.5 (CH), 130.4 (CH), 129.9 (CH), 129.2 (CH), 129.0 (q), 126.5 (CH), 123.1 (q), 122.9 (q), 120.8 (CH), 117.8 (q), 117.3 (q), 110.5 (CH); IR (KBr, cm^{-1}): 1606, 1483, 1438, 1384, 1352, 1257, 1166; HRMS [M+H]$^+$ found = 330.9633; $C_{15}H_8BrClN_2$ required 330.9637.

10-Chloro-2*H*,6*H*-[1,3]dioxolo[4,5-*g*]indolo[2,3-*b*]quinoline (10c): beige powder (83 mg, 28%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 11.90 (s, 1H, NH), 9.08 (s, 1H, H-11), 7.60 (s, 1H, H-12), 7.55 – 7.40 (m, 2H, H-8 and H-7), 7.34 (s, 1H, H-4), 7.27 (d, 1H, *J* = 7.9 Hz, H-9), 6.20 (s, 2H, CH_2); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 151.8 (q), 151.1 (q), 145.7 (q), 145.2 (q), 142.2 (q), 129.2 (CH), 128.6 (CH), 128.4 (q), 120.4 (q), 120.2 (CH), 118.0 (q), 114.4 (q), 110.2 (CH), 104.3 (CH), 103.9 (CH), 102.2 (CH_2); IR (KBr, cm^{-1}): 1610, 1491, 1464, 1435, 1379, 1255, 1230, 1192, 1161, 1035; HRMS [M+H]$^+$ found = 297.0426; $C_{16}H_9ClN_2O_2$required 297.0431.

10-Chloro-2,3-dimethoxy-6*H*-indolo[2,3-*b*]quinoline (10d): brown powder (184 mg, 59%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 11.86 (s, 1H, NH), 9.11 (s, 1H, H-11) 7.61 (s, 1H, H-1), 7.51 – 7.42 (m, 2H, H-8 and H-7), 7.36 (s, 1H, H-4), 7.27 (dd, 1H, *J* = 7.3 and 1.2 Hz, H-9), 3.96. (s, 3H, 3-*O*CH_3), 3.93. (s, 3H, 2-*O*CH_3); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 153.0 (q), 151.7(q) 147.7 (q), 144.0 (q), 142.2 (q), 128.6 (CH), 128.5 (CH), 128.3 (q), 120.0 (CH), 119.2 (q), 118.1 (q), 114.4 (q), 110.1 (CH), 107.4 (CH), 106.5 (CH), 56.1 (*O*CH_3), 56.0 (*O*CH_3); IR (KBr, cm^{-1}): 1610, 1494, 1431, 1365, 1265, 1242, 1205, 1153, 1014. HRMS [M+H]$^+$ found = 313.0738; $C_{17}H_{13}ClN_2O_2$ required 313.0744.

2-Bromo-10-chloro-6*H*-indolo[2,3-*b*]quinoline (10e): brown powder (244 mg, 74%); ^{1}H-NMR (500 MHz, DMSO-d_6): δ 12.17 (s, 1H, NH), 9.30 (s, 1H, H-11) 8.53 (d, 1H, *J* = 2.3 Hz, H-1), 7.94 (d, 1H, *J* = 9.0 Hz, H-4), 7.86 (dd, 1H, *J* = 9.0 and 2.3 Hz, H-3), 7.57 (t, 1H, *J* = 7.9 Hz, H-8), 7.50 (dd, 1H, *J* = 7.9 and 0.8 Hz, H-7), 7.35 (dd, 1H, *J* = 7.9 and 0.8 Hz, H-9); ^{13}C-NMR (125 MHz, DMSO-d_6): δ 153.0 (q), 145.4 (q), 143.4 (q), 132.6 (CH), 131.3 (CH), 130.0 (CH), 129.6 (CH), 129.5 (CH), 129.2 (q), 125.5 (q), 120.8 (CH), 117.8 (q), 117.5 (q), 115.8 (q), 110.5 (CH); IR (KBr, cm^{-1}): 1606, 1573, 1442, 1348, 1252, 1165, 1064. HRMS [M+H]$^+$ found = 330.9630; $C_{15}H_8BrClN_2$ required 330.9637.

10-Chloro-1-methoxy-6*H*-indolo[2,3-*b*]quinoline (10f): orange powder (254 mg, 90%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 12.07 (s, 1H, *N*H), 9.44 (s, 1H, H-11), 7.69 (t, 1H, *J* = 8.3 Hz, H-3), 7.58 (d, 1H, *J* = 8.3 Hz, H-4), 7.54 (t, 1H, *J* = 8.0 Hz, H-8), 7.49 (dd, 1H, *J* = 8.0 and 0.9 Hz, H-7), 7.33 (dd, 1H, *J* = 8.0 and 0.9 Hz, H-9), 6.98 (d, 1H, *J* = 8.3 Hz, H-2), 4.07 (s, 3H, *O*CH$_3$), ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 156.1 (q), 152.9 (q), 147.7 (q), 143.0 (q), 130.1 (CH), 129.4 (CH), 128.7 (q), 124.2 (CH), 120.4 (CH), 119.9 (CH), 118.1 (q), 116.0 (q), 115.8 (q), 110.4 (CH), 102.2 (CH), 56.4 (*O*CH$_3$); IR (KBr, cm^{-1}): 3404, 1608, 1585, 1440, 1361, 1263, 1220, 1100, 1016. HRMS [M+H]$^+$ found = 283.0635; $C_{16}H_{11}ClN_2O$ required 283.0638.

10-Methoxy-6*H*-indolo[2,3-*b*]quinoline (10g): brown powder (114 mg, 46%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 11.72 (s, 1H, NH), 8.89 (s, 1H, H-11), 8.14 (dd, 1H, *J* = 8.2 and 1.3 Hz, H-1), 7.96 (d, 1H, *J* = 8.2 Hz, H-4), 7.70 (td, 1H, *J* = 8.2 and 1.3 Hz, H-3), 7.48 (t, 1H, *J* = 8.0 Hz, H-8), 7.46. (td, 1H, *J* = 8.2 and 1.3 Hz, H-2), 7.10 (d, 1H, *J* = 8.0 Hz, H-7), 6.86 (d, 1H, *J* = 8.0 Hz, H-9), 4.09. (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 157.0 (q), 152.9 (q) 146.1 (q), 143.2 (q), 130.0 (CH), 129.1 (CH), 129.0 (CH), 128.8 (CH), 127.4 (CH), 124.4 (q), 123.2 (CH), 117.4 (q), 109.2 (q), 104.3 (CH), 102.0 (CH), 56.1 (*O*CH$_3$); IR (KBr, cm^{-1}): 1610, 1593, 1404, 1388, 1313, 1244, 1101. HRMS [M+H]$^+$ found = 249.1024; $C_{16}H_{12}N_2O$ required 249.1028.

10-Methoxy-2*H*,6*H*-[1,3]dioxolo[4,5-*g*]indolo[2,3-*b*]quinoline (10h): brown powder (199 mg, 68%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 11.56 (s, 1H, NH), 8.73 (s, 1H, H-11) 7.53 (s, 1H, H-12), 7.42 (t, 1H, *J* = 8.0 Hz, H-8), 7.31 (s, 1H, H-4), 7.07 (d, 1H, *J* = 8.0 Hz, H-7), 6.81 (d, 1H, *J* = 8.0 Hz, H-9), 6.17 (s, 2H, CH$_2$), 4.06. (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 156.6 (q), 151.7(q) 150.3 (q), 145.3 (q), 144.1 (q), 142.3 (q), 129.0 (CH), 128.3 (CH), 120.0 (q), 115.1 (q), 109.3 (q), 104.3 (CH), 104.0 (2 x CH), 102.0 (CH$_2$), 101.6 (CH), 56.0 (*O*CH$_3$); IR (KBr, cm^{-1}): 2901, 1612, 1460, 1278, 1247, 1224, 1097, 1037. HRMS [M+H]$^+$ found = 293.0923; $C_{17}H_{12}N_2O_3$ required 293.0926.

2-Bromo-10-methoxy-6*H*-indolo[2,3-*b*]quinoline (10i): brown powder (91 mg, 28%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 11.84 (s, 1H, NH), 8.98 (s, 1H, H-11) 8.42 (d, 1H, *J* = 2.3 Hz, H-1), 7.90 (d, 1H, *J* = 9.0 Hz, H-4), 7.78 (dd, 1H, *J* = 9.0 and 2.3 Hz, H-3), 7.51 (t, 1H, *J* = 8.1 Hz, H-8), 7.10 (d, 1H, *J* = 8.1 Hz, H-7), 6.87 (d, 1H, *J* = 8.1 Hz, H-9), 4.09. (s, 3H, *O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 157.1 (q), 153.0 (q) 144.7 (q), 143.4 (q), 131.5 (CH), 130.8 (CH), 130.5 (CH), 129.5 (CH), 128.2 (CH), 125.8 (q), 118.1 (q), 115.4 (q), 109.0 (q), 104.4 (CH) 102.3 (CH), 56.2 (*O*CH$_3$); IR (KBr, cm^{-1}): 1612, 1448, 1402, 1280, 1247, 1097. HRMS [M+H]$^+$ found = 327.0130; $C_{16}H_{11}BrN_2O$ required 327.0134.

2,3,10-Trimethoxy-6*H*-indolo[2,3-*b*]quinoline (10j): brown powder (135 mg, 44%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 11.51 (s, 1H, NH), 8.75 (s, 1H, H-11) 7.54 (s, 1H, H-1), 7.41 (t, 1H, *J* = 8.0 Hz, H-8), 7.33 (s, 1H, H-4), 7.06 (d, 1H, *J* = 8.0 Hz, H-7), 6.81 (d, 1H, *J* = 8.0 Hz, H-9), 4.07. (s, 3H, 10-*O*CH$_3$), 3.94 (s, 3H, 3-*O*CH$_3$), 3.91 (s, 3H, 2-*O*CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 156.6 (q), 152.1 (q) 151.7 (q), 147.3 (q), 143.0 (q), 142.3 (q), 128.8 (CH), 127.7 (CH), 119.3 (q), 115.1 (q), 109.5 (q), 107.2 (CH), 106.7 (CH), 104.2 (CH), 101.5 (CH), 56.0 (3 x *O*CH$_3$); IR (KBr, cm^{-1}): 1614, 1500, 1392, 1255, 1234, 1145, 1097. HRMS [M+H]$^+$ found = 309.1236; $C_{18}H_{16}N_2O_3$ required 309.1239.

1,10-Dimethoxy-6*H*-indolo[2,3-*b*]quinoline (10k): orange powder (120 mg, 43%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 11.74 (s, 1H, *N*H), 9.11 (s, 1H, H-11), 7.60 (t, 1H, *J* = 8.3 Hz, H-3), 7.54 (d, 1H, *J* = 8.3 Hz, H-4), 7.47 (t, 1H, *J* = 8.0 Hz, H-8), 7.10 (d, 1H, *J* = 8.0 Hz, H-7), 6.92 (d, 1H, *J* = 8.0 Hz, H-9), 6.86 (d, 1H, *J* = 8.3 Hz, H-2), 4.09 (s, 3H, 10-*O*CH$_3$), 4.05 (s, 3H, 1-*O*CH$_3$), ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 156.8 (q), 155.9 (q), 152.9 (q), 147.0 (q), 143.0 (q), 129.7 (CH), 128.9 (CH), 123.3 (CH), 119.9 (CH), 116.4 (q), 116.3 (q), 109.5 (q), 104.3 (CH), 102.0 (CH), 101.9 (CH) 56.3 (*O*CH$_3$), 56.2 (*O*CH$_3$); IR (KBr, cm^{-1}): 1612, 1585, 1502, 1406, 1361, 1249, 1099. HRMS [M+H]$^+$ found = 279.1126; $C_{17}H_{14}N_2O_2$ required 279.1133.

9-Fluoro-3-(piperidin-1-yl)[1]benzothiopyrano[2,3-*b*]indole (11a): red powder (161 mg, 48%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.79 (s, 1H, H-11), 7.91 (dd, 1H, *J* = 8.7 and 2.6 Hz, H-10), 7.89 (d, 1H, *J* = 8.8 Hz, H-1), 7.56 (dd, 1H, *J* = 8.7 and 4.6 Hz, H-7), 7.48 (dd, 1H, *J* = 8.8 and 2.4 Hz, H-4), 7.27 (dd, 1H, *J* = 8.8 and 2.4 Hz, H-2), 7.25 – 7.21 (m, 1H, H-8), 3.57 – 3.50 (m, 4H, Pip-6' and 2'H), 1.68 – 1.58 (m, 6H, Pip-5', 4' and 3'H); ^{19}F-NMR (376 MHz, DMSO-*d*$_6$): δ -121.56 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 135.4 (CH), 135.2 (CH), 118.9 (CH), 114.7 (CH), 114.2 (CH), 109.6 (CH), 107.2 (CH), 48.2 (2 x *N*CH$_2$), 25.4 (2 x CH$_2$), 24.4 (CH$_2$); IR (KBr, cm^{-1}): 2944, 1590, 1514, 1452, 1388, 1211, 1178, 1107. HRMS [M+H]$^+$ found = 337.1171; $C_{20}H_{17}FN_2S$ required 337.1174.

8-Chloro-3-(piperidin-1-yl)[1]benzothiopyrano[2,3-*b*]indole (11b): orange powder (187 mg, 54%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.76 (s, 1H, H-11), 8.07 (d, 1H, *J* = 8.1 Hz, H-10), 7.93 (d, 1H, *J* = 9.0 Hz, H-1), 7.60 (d, 1H, *J* = 1.7 Hz, H-7), 7.46 (d, 1H, *J* = 2.3 Hz, H-4), 7.28 (dd, 1H, *J* = 8.1 and 1.7 Hz H-9), 7.26 (dd, 1H, *J* = 9.0 and 2.3 Hz H-2), 3.58 – 3.49 (m, 4H, Pip-6' and 2'H), 1.72 – 1.60 (m, 6H, Pip-5', 4' and 3'H); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 135.1 (CH), 134.9 (CH), 121.7 (CH), 121.6 (CH), 118.0 (CH), 114.4 (CH), 109.6 (CH), 48.3 (2 x *N*CH$_2$), 25.4 (2 x CH$_2$), 24.4 (CH$_2$); IR (KBr, cm^{-1}): 2942, 1591, 1384, 1361, 1232, 1192, 1124, 1057. HRMS [M+H]$^+$ found = 353.0876; $C_{20}H_{17}ClN_2S$ required 353.0879.

8-Chloro-3-(morpholin-4-yl)[1]benzothiopyrano[2,3-*b*]indole (11c): red powder (188 mg, 53%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.81 (s, 1H, H-11), 8.10 (d, 1H, *J* = 8.0 Hz, H-10), 7.99 (d, 1H, *J* = 8.9 Hz, H-1), 7.62 (d, 1H, *J* = 1.8 Hz, H-7), 7.52 (d, 1H, *J* = 2.5 Hz, H-4), 7.31 (dd, 1H, *J* = 8.9 and 2.5 Hz, H-2), 7.30 (dd, 1H, *J* = 8.0 and 1.8 Hz, H-9), 3.78 (t, 4H, *J* = 4.7 Hz, Mor-6' and 2'H), 3.47 (t, 4H, *J* = 4.7 Hz, Mor-5' and 3'H); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 162.0 (q), 155.4 (q), 152.6 (q), 136.5 (q), 135.0 (CH), 134.8 (CH), 132.3 (q), 125.8 (q), 125.3 (q), 122.0 (CH), 121.8 (CH), 118.2 (CH), 118.1 (q), 114.4 (CH), 110.0 (CH), 66.3 (2 x *O*CH$_2$), 47.4 (2 x *N*CH$_2$); IR (KBr, cm^{-1}): 1610, 1535, 1444, 1373, 1192, 1058. HRMS [M+H]$^+$ found = 355.0669; $C_{19}H_{15}ClN_2OS$ required 355.0672.

3-(4-Ethylpiperazin-1-yl)-9-fluoro[1]benzothiopyrano[2,3-*b*]indole (11d): red powder (293 mg, 80%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.76 (s, 1H, H-11), 7.92 (d, 1H, *J* = 8.8 Hz, H-1), 7.90 (dd, 1H, *J* = 8.8 and 2.7 Hz, H-10), 7.56 (dd, 1H, *J* = 8.8 and 4.6 Hz, H-7), 7.47 (d, 1H, *J* = 2.5 Hz, H-4), 7.27 (dd, 1H, *J* = 8.8 and 2.5 Hz, H-2), 7.24 (ddd, 1H, *J* = 8.8, 2.5 and 0.8 Hz, H-8), 3.50 (t, 4H, *J* = 4.8 Hz, Pz-6' and 2'H), 2.55 (t, 4H, *J* = 4.8 Hz, Pz-5' and 3'H), 2.43 (q, 2H, *J* = 7.0 Hz, *N*CH$_2$), 1.06 (t, 3H, *J* = 7.0 Hz, CH$_3$); ^{19}F-NMR (376 MHz, DMSO-*d*$_6$): δ -121.39 (s, 1F); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 135.1 (CH), 135.0 (CH), 119.0 (CH), 114.9 (CH), 114.3 (CH), 110.0 (CH), 107.2 (CH), 52.5 (2 x *N*CH$_2$), 51.9 (*N*CH$_2$), 47.1 (2 x *N*CH$_2$), 12.3 (CH$_3$); IR (KBr, cm^{-1}): 2817, 1595, 1452, 1383, 1251, 1174, 1112. HRMS [M+H]$^+$ found = 366.1435; $C_{21}H_{20}FN_3S$ required 366.1440.

8-Chloro-3-(4-ethylpiperazin-1-yl)[1]benzothiopyrano[2,3-*b*]indole (11e): orange powder (336 mg, 88%); ^{1}H-NMR (500 MHz, DMSO-*d*$_6$): δ 8.80 (s, 1H, H-11), 8.09 (d, 1H, *J* = 8.1 Hz, H-10), 7.97 (d, 1H, *J* = 9.0 Hz, H-1), 7.61 (d, 1H, *J* = 1.8 Hz, H-7), 7.50 (d, 1H, *J* = 1.8 Hz, H-4), 7.32 – 7.27 (m, 2H, H-9 and H-2), 3.51 (t, 4H, *J* = 4.7 Hz, Pz-6' and 2'H), 2.57 – 2.54 (m, 4H, Pz-5' and 3'H), 2.45 – 2.41 (m, 2H, *N*CH$_2$), 1.07 (t, 3H, *J* = 7.1 Hz, CH$_3$); ^{13}C-NMR (125 MHz, DMSO-*d*$_6$): δ 135.0 (CH), 134.8 (CH), 121.9 (CH), 121.8 (CH), 118.1 (CH), 114.5 (CH), 110.0 (CH), 52.5 (2 x *N*CH$_2$), 51.8 (*N*CH$_2$), 47.1 (2 x *N*CH$_2$), 12.2 (CH$_3$); IR (KBr, cm^{-1}): 2810, 1591, 1512, 1386, 1365, 1236, 1193, 1128, 1056. HRMS [M+H]$^+$ found = 382.1141; $C_{21}H_{20}ClN_3S$ required 382.1144.

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